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DEPARTMENT OF AEROSPACE ENGINEERING

Guide to Graduate Studies

2003 / 2004

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PREFACE

This Guide to Graduate Study provides information about the graduate degree program in the Aerospace Engineering Department of the Pennsylvania State University. It is intended to serve as an introduction to the program for new graduate students and as a reference resource for continuing graduate students, faculty, and staff of the department. It is designed to supplement the Graduate Degree Programs Bulletin (henceforth referred to as "the Bulletin"), issued by the Graduate School, which is the primary reference document for graduate study at Penn State. Inquiries about the Bulletin and its contents should be addressed to:

Graduate Enrollment Services (GES)
The Pennsylvania State University
114 Kern Graduate Building
University Park, PA 16802
Phone: (814) 865-1795
http://www.gradsch.psu.edu

A brief overview of Penn State University, the Graduate School, the College of Engineering, and the Department of Aerospace Engineering is provided in the Introduction. The Introduction also describes the admission process as well as expenses and financial aid.

The Aerospace Graduate Program and Academic Requirements and Guidelines are next discussed in Sections II and III, respectively. Section IV presents the faculty and laboratory staff of the department. Any questions regarding the Aerospace Graduate program should be addressed to:

Ms. Robin Grandy
Graduate Program Staff Assistant
Department of Aerospace Engineering
The Pennsylvania State University
229 Hammond Building
University Park, PA 16802
Phone: (814) 865-6431
Fax: (814) 865-7092
rig1@psu.edu

Additional sources of useful information for graduate students may be obtained by contacting:

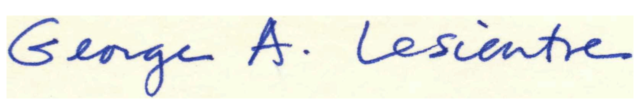
International Students & Scholars (ISS)
The Pennsylvania State University
410 Boucke Building
University Park, PA 16802
Phone: (814) 865-6348
Fax: (814) 865-6480
http://www.international.psu.edu

Student Health Insurance Office
The Pennsylvania State University
320 Grange Building
University Park, PA 16802
(814) 865-7467
Fax: (814) 863-1390
http://www.sa.psu.edu/UHS/insurance.htm

Student Affairs Off-Campus Living
The Pennsylvania State University
211 HUB-Robeson Center
University Park, PA 16802
Phone: (814) 865-2346
email: jbw7@sa.psu.edu
http://www.sa.psu.edu/ocl/

Office of Disability Services
116 Boucke Building
University Park, PA 16802-5902
Phone: (814) 863-1807 (Voice or TTY)
Fax: (814) 863-3217
http://www.equity.psu.edu/ods/

To the incoming graduate students of the Department, I welcome you all on behalf of the Department of Aerospace Engineering and wish you success in your studies.



George A. Lesieutre
Professor and Director of Graduate Studies

INTRODUCTION

The University and Graduate School

The Pennsylvania State University (http://www.psu.edu) is a land-grant University serving the Commonwealth of Pennsylvania from a number of campuses located throughout the State. The central campus, located at University Park, offers undergraduate and graduate education and research through its Colleges of Agricultural Sciences, Arts and Architecture, Business Administration, Earth and Mineral Sciences, Education, Engineering, Health and Human Development, Liberal Arts, and Science, and the School of Communications.

The Graduate School (http://www.gradsch.psu.edu) administers for the University all graduate programs in the various Colleges and Schools. Among other functions, it provides a common admission process for all graduate programs and administers a number of graduate fellowship programs.

The College of Engineering

Aerospace Engineering is a department within the College of Engineering (http://www.engr.psu.edu) which is also home for 18 other departments and a number of specialty programs and research units. The Associate Dean for Graduate Studies and Research provides a liaison between the graduate programs within the college and the Graduate School and external research sponsoring organizations. A number of College of Engineering Fellowships are also administered from the Dean's Office.

The Aerospace Engineering Department

The Department (http://www.aero.psu.edu) provides undergraduate and graduate educational programs in all the major disciplines of aerospace sciences: aerodynamics, structures, guidance, dynamics and control, and propulsion. It promotes and supports vigorous research by its faculty members with assistance from graduate students, and maintains a number of experimental and computational research facilities.

It is administered by the Department Head (Prof. Dennis K. McLaughlin), Administrative Assistant (Ms. Sheila Corl), clerical staff, and faculty directors of undergraduate and graduate studies and admission. The Director of Graduate Studies (Prof. George A. Lesieutre) is responsible for the admission of new graduate students into the graduate program, the graduate courses, and Doctoral Candidacy Examination. He is assisted by the Graduate Program Staff Assistant (Ms. Robin Grandy).

Graduate programs lead to the Master of Science (M.S.), Master of Engineering (M.Eng.), or Doctor of Philosophy (Ph.D.) degrees.

Expenses and Financial Aid

General Expenses

The tuition rate for 12 credits or more at the University Park Campus is currently $5,523 per semester for Pennsylvanians and $10,447 per semester for non-Pennsylvanians. For 11 or fewer credits, it is $443 per credit for in-state residents and $854 per credit for out-of-state residents. Room and board charges for a standard double- or single-occupancy dormitory average $3,770 and $4,055,per semester. **On-campus housing** for graduate students includes the following:

> Eastview Terrace, located within walking distance of downtown, has 811 a/c single rooms with a private bathroom and a refrigerator/microwave. Rooms are clustered in groups of 8 to 16 – with laundry facilities and a study/social space in each cluster. Electricity, heat, and water – and TV, phone and Internet connections – are included in the room rate. A Housing Contract is signed so you are only obligated to the contract for the time you are a registered student.
>
> Graduate Circle offer one- and two-bedroom unfurnished apartments, clustering in two areas on the north side of campus on Hastings Road. There are 216 two-story apartments. Residents are predominantly international graduate students with families. Single graduate students comprise the next largest group of residents, followed by undergraduates with a fifth-semester standing or higher.

Nittany Apartments, located on campus, accommodates four single students of the same gender in each apartment. Two apartments are equipped for disabled student use, and each will accommodate three students of the same gender if occupied by a disabled student. Residents are within a block or two of the ice-skating rink, swimming pools, tennis courts, the varsity track and field facility, Indoor Sports Complex, Eisenhower Auditorium, and the HUB-Robeson Center (student union). Each bedroom includes a chest of drawers, desk with light, desk chair, bookshelf, bed with mattress, TV cable, and individual door lock. The Living/Dining room includes a table and four chairs, two-seater couch, two easy chairs, two end tables, two table lamps, a floor lamp, coffee table, TV cable. Kitchen includes a stove with oven, refrigerator and garbage disposal.

White Course Apartments, are located on the west side of campus near the bus station. Single apartments feature 75 four-bedroom units with common areas for 300 residents. Students with families can enjoy one-bedroom (sixty standard units and eight corner units), two bedroom townhouses (forty-two two-story units and three one-story garden apartments), or a three-bedroom townhouse (four two-story units and one one-story garden apartment). Each unit features bedroom(s), bathroom(s), living room, kitchen, and laundry area and all come unfurnished.

For additional information about living accommodations, meal tickets, and "Lion Cash", contact the Assignment Office for Campus Residences, 101 Shields Building, (814) 865-7501 or http://www.hfs.psu.edu.

Graduate students should arrange for their accommodations well in advance of the beginning of classes because it may be quite difficult to find convenient housing at the last minute. Students must be admitted to the Graduate School before their requests for on-campus living accommodations can be processed. An application for on-campus housing accompanies the letter of admission to a graduate degree program.

Off-campus housing is available at various prices within the greater community. Information about these can be obtained by accessing http://www.sa.psu.edu/ocl/ or by contacting Student Affairs, 211 HUB-Robeson Center, at (814) 865-2346.

Medical Insurance

The University **requires medical insurance** for all international students enrolled at Penn State and their accompanying dependents (spouse and/or children). Graduate assistants/fellows will be placed on the Penn State student insurance plan underwritten by the Mega Life and Health Insurance Company. The University will pay 80% of the premium and the remaining 20% of the premium will be deducted from a graduate assistant's paycheck. This will be deducted from your pay automatically each month in the amount of $20.30 for the Fall 2003 semester starting with the September 2003 stipend check and $28.36 for the Spring 2004 semester starting with the January 2004 stipend check. If you do not receive a paycheck in September (Fall semester) two months of insurance premium will be deducted from your October 2003 stipend check or in January (Spring semester) two months of insurance premium will be deducted from your February 2004 stipend check. Students may choose coverage other than the Mega Health Insurance plan provided they meet certain criteria.

Penn State now covers 70% of your dependent's insurance costs, while the remaining 30% will be deducted monthly from your stipend check.

Spouse:	FALL 2003 – $82.50 per month	SPRING/SUMMER 2004 - $115.32 per month
Children:	FALL 2003 – $52.72 per month	SPRING/SUMMER 2004 - $73.80 per month
Family:	FALL 2003 – $155.52 per month	SPRING/SUMMER 2004 - $217.48 per month

Students that are self-supported will pay an annual medical insurance fee of $799.00. This can be waived if the student provides evidence of other suitable medical insurance.

	Student	Spouse	Each Child
Annual	$799.00	$2,875.00	$1,278.00
Fall	304.00	1,093.00	486.00
Spring/Summer	511.00	1,839.00	817.00
First Six-Week Summer Session	234.00	840.00	374.00
Second Six Week Summer Session	136.00	491.00	218.00

Penn State will not supplement nor will a payroll deduction be made for insurance policies other than the Penn State Graduate Assistant Graduate Fellow Plan.

Graduate Assistants / Fellows can enroll for a vision plan at no additional cost. This service is not automatic so you will need to complete the needed form kept in 320 Grange Building.

Self-supported students have the option of purchasing vision insurance for $29.00 per year or $58.00 per year for student and family.

Please contact the Student Insurance Office at 320 Grange Building or http://www.sa.psu.edu/uhs/ to arrange your medical insurance or if additional information is needed http://www.student-resources.net/.

Financial Aid

Many opportunities exist for financial support. There are graduate assistantships, fellowships and traineeships, graduate school tuition assistance (for summer semester) and employment and loan programs available through the Office of Student Aid.

Half-time teaching and research assistantships are available within the department on a competitive basis, carrying a stipend plus paid tuition. In 2003 - 2004, the half-time graduate stipend amount is $12,915 (M.S.) or $13,905 (Ph.D.) for two semesters. The student on a half-time assistantship normally schedules 12 credits per semester and performs tasks that, on average, occupy approximately 20 hours per week. For M.S. or M.Eng. degree candidates working as teaching assistants, the duration of this support is typically two years, without tuition in the fourth semester. Most research assistantships are also available during the summer, offering an additional stipend which, in 2003 – 2004, amounts to $4,230 (M.S.) or $4,539 (Ph.D.). Nearly all assistantships are half-time. However, quarter-time or three-quarter time assistantships may be arranged for special needs. An application for an assistantship may be obtained from the Graduate Program Staff Assistant (Ms. Robin Grandy).

For financial aid other than the aforementioned assistantships, the prospective student should refer to The Graduate School's website: http://www.gradsch.psu.edu/fellow/.

TAs, RAs & TAides

- COURSE ASSIGNMENTS – Any questions see Director of Graduate Studies.
- 20 Hrs/Week for 1/2-time TA/TAide
- 10 Hrs/Week for 1/4 –time TA/TAide
- **TAs & RAs should register for the maximum number of 12 credits – (3 courses, 3 credits AERSP 600).**
- TAs should meet with their assigned course instructors ASAP for instructions
- Foreign nationals were required to take the oral language SPEAK test (formerly Test of Spoken English) if they are serving as a TA/TAide (results for this semester were given to the students involved). Please see the Director of Graduate Studies to discuss results.
- TAs actually teaching (i.e. lab courses 405/406) should take ENGR 588 (1 cr.) this semester. The remaining TAs should take the Grader's Seminar offered on Monday, September 29th. Please see the Graduate Program Staff Assistant for more details and registration.
- TAs & TAides are evaluated by supervisors at end of each semester. This information is used by the Director of Graduate Studies & the Department Head for making future selections.
- The Department of Aerospace Engineering frequently supports M.S. and M.Eng. students as Teaching Assistants (TA). Our practice is to provide such Teaching Assistant support for three (3) semesters, followed by one (1) semester of support as a Teaching Aide. The Teaching Aide is a wage payroll position.

  A Teaching Aide position provides students with support equivalent to that of the Teaching Assistant stipend, with reduced support for tuition. Thus, TAs are expected to substantially complete their course requirements in the first three semesters; this involves enrolling for approximately 10-12 credits per semester.

Students may want to apply for the Tuition Assistance Program in the Summer Session 2004 to maximize tuition monies.

- ✧ TA and RA monthly stipends will be deposited into personal bank accounts on the last working day of each month.

TAides and RAides

Students will be paid via wage payroll, on a bi-weekly pay schedule, and will be responsible for their tuition and health insurance expenses.

Departmental Student Organizations

American Institute of Aeronautics and Astronautics (AIAA)

The AIAA is the largest American technical society devoted to science and engineering in the fields of space, technology, rocket systems, aerodynamics, and marine systems. Students are encouraged to join the Penn State Student Branch of the AIAA. Membership applications and information on the benefits of belonging to this organization may be obtained from the AIAA faculty advisor. Meetings and social events (including a picnic) are held regularly during the academic year. Members can also attend the annual student conference for the Mid-Atlantic Region each April. Listen for announcements in class and watch the Aerospace bulletin board for notices. Dr. Robert G. Melton, 229B Hammond, is the faculty advisor to the PSU Student Branch of the AIAA for the 2003/04 academic year.

American Helicopter Society (AHS)

The American Helicopter Society student chapter is the Department's newest organization, having received its charter from the parent organization in July 1980. Our AHS student chapter is now one of the largest and most active chapters in the country. If you are interested in joining the AHS, please watch the Aerospace bulletin board for meeting notices or contact Dr. Edward C. Smith, the faculty advisor to the PSU student branch. Dr. Smith's office is in Room 231D Hammond Building.

Aerospace Graduate Student Association (AeroGSA)

As an organization, AeroGSA plays a number of important roles within the Department of Aerospace Engineering at Penn State:

AeroGSA provides a means of communication between graduate students and the faculty and administration of the department. In previous years, this communication has been instrumental in improving the environment for graduate students within the department.

AeroGSA provides social opportunities such as IM sports teams, movies, mixers, and other activities. It enables students from different parts of the department (and world!) who might not interact much in the normal course of events to get to know one another better.

AeroGSA provides service to the graduate student population and the department at large. In previous years, AeroGSA has assisted with the graduate open house in the spring, and with new student orientation in the fall. There are great opportunities in AeroGSA for students who care about making a difference.

Contact the AeroGSA Officers to find out how you can get involved.

Engineering Graduate Student Council (EGSC)

The Penn State Engineering Graduate Student Council (EGSC) strives to promote and enhance graduate studies in the College of Engineering by providing a forum for open discussion and by serving as a communication link between students, faculty, and administrators within the College. EGSC is comprised of representatives from each of the 15 Engineering Departments. AeroGSA selects a representative to the EGSC.

LIST OF AEROSPACE FACULTY

Name	Title	Office	Phone	E-Mail
Dr. Anthony K. Amos	Professor Emeritus	224 Hammond	863-0778	aka@psu.edu
Dr. Kenneth S. Brentner	Associate Professor	233D Hammond	865-6433	ksbrentner@psu.edu
Dr. Cengiz Camci	Professor	233 Hammond	865-9871	c-camci@psu.edu
Dr. Farhan S. Gandhi	Associate Professor	231C Hammond	865-1164	fgandhi@psu.edu
Dr. J. William Holl	Professor Emeritus	224 Hammond	865-8453	jwh8@psu.edu
Dr. Joseph F. Horn	Assistant Professor	233G Hammond	865-6434	joehorn@psu.edu
Dr. Robert F. Kunz	Adjunct Assistant Professor	165 ARL	865-2144	rfk102@psu.edu
Dr. George A. Lesieutre	Professor & Director of Graduate Studies	229A Hammond	863-0103	g-lesieutre@psu.edu
Dr. Deborah A. Levin	Associate Professor	233E Hammond	865-6435	dalevin@psu.edu
Dr. Geoffrey Lilley	Adjunct Professor U. of Southhampton	NASA Langley		
Dr. Lyle N. Long	Professor	229C Hammond	865-1172	lnl@psu.edu
Dr. Mark D. Maughmer	Professor	233F Hammond	863-4485	mdm@psu.edu
Dr. Barnes W. McCormick	Boeing Professor Emeritus	231B Hammond	863-0602	bwmaer@engr.psu.edu
Dr. Dennis K. McLaughlin	Professor & Department Head	222A Hammond	865-2560	dkmaer@engr.psu.edu
Dr. Robert G. Melton	Professor & Dir. of Undergrad. Studies	229B Hammond	865-1185	rgmelton@psu.edu
Dr. Michael M. Micci	Professor	230C Hammond	863-0043	micci@psu.edu
Dr. Philip J. Morris	Boeing / A.D. Welliver Professor	233C Hammond	863-0157	pjm@psu.edu
Dr. Edward C. Smith	Associate Professor	231D Hammond	863-0966	ecs@rcoe.psu.edu
Dr. Hubert C. Smith	Associate Professor Emeritus	230B Hammond	865-7783	hcsaer@engr.psu.edu
Dr. David B. Spencer	Assistant Professor	233H Hammond	865-4537	dbs9@psu.edu

LABORATORY STAFF

Name	Title	Room	Phone	E-mail
Mr. Richard R. Auhl	Laboratory Director and Instructor	226 Hammond	865-5381	rraaer@engr.psu.edu
Mr. Mark S. Catalano	Computer & Electronics Coordinator	226 Hammond	865-5703	mac9@psu.edu
Mr. Abraham Mathew	Computer Specialist	48 Hammond	865-5703	axm153@psu.edu

LIST OF AEROSPACE STAFF

Name	Title	Room	Phone	E-Mail
Ms. Jane Auhl	Software Systems Assistant	222 Hammond	863-0065	jea5@psu.edu
Ms. Kathy Barr	Department Head Staff Assistant	225A Hammond	865-2560	kbarr@engr.psu.edu
Ms. Tammy Besecker	Part-Time Administrative Assistant	222 Hammond	865-2569	tdb1@psu.edu
Ms. Sheila Corl	Administrative Assistant	227A Hammond	865-6997	sxi1@psu.edu
Ms. Nancy English	Bookkeeper (Petty cash, purchases, wage-payroll, travel)	227 Hammond	863-1077	nec101@psu.edu
Ms. Robin Grandy	Graduate Program Staff Assistant	229 Hammond	865-6431	rig1@psu.edu
Ms. Debbie Jacobs	Staff Assistant for IHPCA & Rotorcraft Centers	233B Hammond	865-1966	daj122@psu.edu
Ms. Janice Sherer	Undergraduate Program Staff Assistant	229 Hammond	865-6432	jhs14@psu.edu
Ms. Marilyn Warrender	Department Staff Assistant	225 Hammond	865-2569	mvw1@psu.edu
Ms. Debbie Witherite	Accounting Clerk (Keys, assistantships)	227B Hammond	865-1043	djw4@psu.edu

II. THE AEROSPACE GRADUATE PROGRAM

Areas of Emphasis

The Department provides coursework and research projects in the following areas of emphasis: analytical/computational fluid dynamics, aeroacoustics, experimental fluid dynamics, flight science and vehicle dynamics, dynamics and control, rotorcraft engineering, structural dynamics/structures and materials, space propulsion, and turbomachinery. Graduate students may combine any number of these in a program leading to the M.Eng., M.S., or Ph.D. degrees.

The student's academic advisor typically works with the student in selecting courses and research areas. A temporary advisor is assigned to each student upon entry into the program. The student is encouraged to subsequently select a permanent advisor from among the faculty after becoming more acquainted with them and their research, preferably by the end of the first semester.

Course Offerings

400 Series-Senior Level Courses

*Technical Elective Courses. Some of these may not be offered every year.

401A ***- Spacecraft Design - Preliminary*** (2) Formulation of conceptual and preliminary design to satisfy a given set of specifications for a spacecraft. Prerequisite: AERSP 309. Prerequisite or concurrent: AERSP 450.

401B ***- Spacecraft Design - Detailed*** (2) Design of primary and secondary structural components and other details of a spacecraft. Prerequisites: AERSP 302, AERSP 401A.

402A ***- Aircraft Design - Preliminary*** (2) Formulation of conceptual and preliminary design to satisfy a given set of specifications for an aircraft. Prerequisite: AERSP 306. Prerequisite or concurrent: AERSP 413.

402B ***- Aircraft Design - Detailed*** (2) Design of primary and secondary structural components and other details of an aircraft. Prerequisites: AERSP 302, AERSP 402A.

*403 ***- Design of Air Transport Systems*** (3) Air transportation; vehicle technology; vehicle-airport-route design interface; ATC, energy, environmental, human, and regulatory considerations in design. Prerequisite: AERSP 306.

*404H ***- Flight Vehicle Design and Fabrication II*** (3) Project management, design, fabrication, aerodynamic and structural testing, and flight evaluation of an advanced composite flight vehicle. Prerequisites: AERSP: 204H Intended for University Schreyer Scholars (juniors and seniors).

405W ***- Aerodynamics Laboratory*** (2) Experiments in fluid mechanics, measurement systems, subsonic and supersonic wind tunnel testing. Prerequisite or concurrent ENGL 202C Prerequisite: AERSP 312.

406W ***- Structures and Dynamics Laboratory*** (2:0:4) Experiments in static deformations and stresses, vibrations, and control of aerospace structures. Prerequisite or concurrent: AERSP 302, ENGL 202C.

*407 ***- Aerodynamics of V/STOL Aircraft*** (3) Rotary wing aircraft; VTOL and STOL performance; propeller-wing combinations; jet flap; high lift devices. Prerequisite: AERSP 312.

410 ***- Aerospace Propulsion*** (3) Analysis and performance characteristics of reciprocating engine, turbo-jet, turbo-prop, turbo-fan, ram-jets, and chemical rockets. Aerothermodynamics of inlets, combustors, and turbomachinery. Prerequisite: AERSP 312.

*412 ***- Turbulent Flow*** (3) Homogeneous turbulence, spectral transfer of energy, viscous dissipation; turbulent shear flow: mixing-length theory, eddy viscosity, scaling laws, energy budget. Prerequisite: one course in fluid mechanics.

413 ***- Stability and Control of Aircraft*** (3) Static and dynamic stability and control of aircraft; open and closed loop systems. Prerequisites: AERSP 304, 306.

*420 ***- Principles of Flight Testing*** (3) In-flight and analytical studies of airplane performance, stability, and control; reduction of data; instrumentation; flight test techniques. Prerequisite: AERSP 306.

[*]421 - ***Intermediate Viscous Flow*** (3) (ME 421) Methods of describing incompressible external flows past objects; internal flows in pipes and ducts; pressure, velocity, and flow rate measurements. Prerequisites: ME 23 or 30; ME 33 or CE 261.

[*]423 **- *Introduction to Numerical Methods in Fluid Dynamics*** (3) Finite difference methods applied to solving viscid/inviscid fluid dynamics problems, error control, and numerical stability. Prerequisites: AERSP 312 or ME 33; CmpSc 201C, 201F; MATH 250 or 251.

[*]424 - ***Introduction to Numerical Methods on Parallel Computers*** (3) This course discusses how to solve a variety of engineering and scientific problems on parallel computers. Prerequisites: MATH 250 or 251, MATH 220, CmpSc 201, or equivalent.

[*]425 **- *Theory of Flight*** (3) Advanced wing and airfoil theory, conformal mapping, slender body theory. Prerequisite: AERSP 306.

[*]430 **- *Space Propulsion and Power Systems*** (3) Analysis and performance of chemical and nuclear rockets, electric propulsion systems. Introduction to solar, chemical, thermoelectric, and nuclear power sources. Prerequisite: AERSP 410 or ME 403.

450 **- *Orbit and Attitude Control of Spacecraft*** (3) Principles of mechanics and vector analysis applied to basic concepts of satellite motion and control, rocket ballistics, and gyroscopic instruments. Prerequisites: AERSP 304, 309.

[*]473 - ***Composites Processing*** (3) (EMch 473) An introduction to the principles of mechanics governing manufacturing, computer-aided design, and testing of composite materials and structures. Prerequisite: EMch 471.

[*]490 - ***Introduction to Plasmas*** (3) (EE 490, NucE 490) Plasma oscillations; collisional phenomena; transport properties; orbit theory; typical electric discharge phenomena. Prerequisite: EE 330 or Phys 467.

[*]492 - ***Space Astronomy and Introduction to Space Science*** (3) (EE 492) The physical nature of the objects in the solar system; the earth's atmosphere, ionosphere, radiation belts, magnetosphere, and orbital mechanics. Prerequisites: Phys 400 or EE 330.

[*]494 **- *Aerospace Undergraduate Thesis*** (1-3 per semester, maximum of 6) Individual problem investigations reported in written thesis and seminar lectures. Cooperative research with faculty guidance on topics of current interest. Prerequisite: seventh-semester standing.

496 – ***Independent Studies*** (1-18)

497 - ***Special Topics*** (1-9)

*497B – ***Object Oriented Programming*** - (3). Java and Linux for Embedded Systems. Java is an object-oriented computer language that was built to run on the world-wide-web and Linux is the fastest growing operating system in the world. Real-time operating systems.

*497G **- *Classical and Modern Controls*** (3) An introduction to the principles, analysis, and design of automatic control systems, frequency domain and time domain techniques, open and closed-loop systems, modeling of physical systems, stability, and optimal control. Prerequisite: AERSP 304 or equivalent.

*497I - ***Spacecraft Environment Interactions***. (3). This course will examine various aspects of spacecraft aerodynamics and interactions with the space environment. The course will include some aspects of spacecraft design and the latest computational methods for calculating spacecraft aerodynamic forces and moments and thruster plume contamination.

*497K - ***Small Scale Turbomachinery Design***. (3). Aero-thermo-mechanical Design of Small Gas Turbine Systems for Unmanned-Aerial Vehicle (UAV) Systems.

[*]Technical Elective Courses. Some of these may not be offered every year.

500 Series - Graduate Level Courses

504 - ***Aerodynamics of V/STOL Aircraft*** (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: AERSP 407.

505 - ***Aero- and Hydroelasticity*** (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506 - ***Rotorcraft Dynamics*** (3) Modeling and analysis techniques for dynamic response, vibration, aeroelastic stability, and aeromechanical stability of rotary wing-vehicles.

507 - ***Theory and Design of Turbomachinery*** (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsions; opportunity to work out design examples.

508 - ***Foundations of Fluid Mechanics*** (3) Mathematical review, fluid properties, kinematics, conservation laws, constitutive relations, similarity principles, the boundary layer, inviscid flow, vorticity dynamics, wave motion.

509 - ***Dynamics of Ideal Fluids*** (3) Irrotational flow theory, two-dimensional and axisymmetric flows, airfoil theory, complex variables, unsteady phenomena; flow with vorticity, finite wing theory. Prerequisite: AERSP 508.

510 - ***Compressible Flow*** (3) Classification and solution of compressible flow problems, high-speed gas dynamics, unsteady motion, transonic and hypersonic flows, atmospheric reentry.

511 - ***Aerodynamically Induced Noise*** (3) Review of fluid mechanics. General theory of aerodynamic sound. Noise radiation from jets, boundary layers, rotors, and fans. Structural response.

512 - ***Viscous Flow*** (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.

514 - ***Stability of Laminar Flows*** (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.

518 - ***Dynamics and Control of Aerospace Vehicles*** (3) Dynamical problems of aircraft and missiles, including launch, trajectory, optimization, orbiting, reentry, stability and control, and automatic control. Prerequisite: AERSP 413 or 450.

524 - ***Homogeneous Turbulence*** (3) (ME 524) First in two-part series. Similarity and scaling, vorticity dynamics; Fourier spectral representation; interscale energy transfer. Numerical simulations and experimental measurement. Prerequisite: a graduate-level course in fluid mechanics.

525 - ***Inhomogeneous Turbulence*** (3) (ME 525) Second in two-part series. Instability and transition; turbulence models; Reynolds stress closure schemes; large eddy simulations; wave models; turbulence measurements. Prerequisite: AERSP 524.

526 - ***Computational Methods for Shear Layers*** (3) (ME 526) Study of numerical solution methods for steady and unsteady laminar or turbulent boundary-layer equations in two and three dimensions. Prerequisite: AERSP 423 or ME 540.

527 - ***Computational Methods in Transonic Flow*** (3) (ME 527) Numerical solution of partial differential equations of mixed type, with emphasis on transonic flows and separating boundary layers. Prerequisite: AERSP 423 or ME 540.

528 - ***Computational Methods for Recirculating Flows*** (3) (ME 528) Numerical solution techniques for laminar/turbulent flow with large recirculation zones. Both primitive variable and stream function-vorticity equations used. Prerequisites: AERSP 423, ME 540.

529 - ***Advanced Analysis and Computation of Turbomachinery Flows*** (3) Review of numerical methods; three-dimensional inviscid flow computation; two-and three-dimensional viscous flow effects and computation; recent advances. Prerequisites: AERSP 423, AERSP 507 or ME 418.

530 - ***Aerothermochemistry of Advanced Propulsion Systems*** (3) Physics and chemistry needed to analyze advanced rocket propulsion systems including reacting high temperature radiating gas and plasma flows. Prerequisites: undergraduate course in compressible gas dynamics such as AERSP 312 or ME 434.

540 - ***Theory of Plasma Waves*** (3) (EE 540, NUC E 540) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: AERSP. (EE, NUC E) 490.

550 - ***Astrodynamics*** (3) Applications of classical celestial mechanics to space flight planning. Determination and construction of orbital parameters by approximation methods. Perturbation techniques. Prerequisite: AERSP 450 or ASTRO 460 or PHYS 419.

553 - ***Foundations of Structural Dynamics and Vibrations*** (3) (ME 553 and EMch 553) Modeling approaches and analysis methods of structural dynamics and vibration. Prerequisites: AERSP 304, EMch 401, ME 440 or 454.

560 - ***Finite Element Method in Fluid Mechanics and Heat Transfer*** (3) Application of finite element techniques to viscous/unsteady fluid flow/heat transfer problems. Prerequisites: AERSP 313, 312.

590 - ***Colloquium (Seminar)*** (3) Presentations of ongoing research in aerospace engineering by faculty and senior doctoral students.

596 - ***Independent Studies*** (1-9) Also used for M.Eng. Scholarly Paper credits (2)

597 - ***Special Topics*** (1-9)

597C – ***Object Oriented Programming***. (3) Java and Linux for Embedded Systems. Java is an object-oriented computer language that was built to run on the world-wide-web and Linux is the fastest growing operating system in the world. Real-time operating systems.

597C - ***Vibration Damping & Control*** (3) Concepts and analysis methods for passive vibration control, with applications to aerospace and mechanical systems. Classification of vibration control problems, typical solution approaches. Vibration isolation, multi-stage and layered isolators; role of damping. Mass and stiffness modifications. Material damping, structural damping treatments, damping models. Tuned vibration absorbers. Shunted piezoelectric elements. Assessing the relative performance of competing approaches.

597D - ***Topics in Applied Aerodynamics*** (3)

597F - ***Smart Structures*** (3) Over the last 10-15 years there has been tremendous interest in the use of smart materials as elements of “adaptive” structures. This class of materials includes, among others, piezoelectric materials, shape memory alloys, and electro- and magneto-rheological fluids. The course covers the fundamental behavior of these materials, their constitutive modeling, develops models for the introduction of smart materials as elements of adaptive structures (in particular for structural vibration reduction, damping augmentation, and shape control or morphing applications), addresses issues such as sizing and optimal placement of actuators and sensors in structures, and examines different control strategies and the resulting system behavior. Several smart materials application case studies are also presented.

597F - ***Behavior of Advanced Composite Structures*** (3) Analysis techniques for composite beams, plates, and shells, energy and finite element formulations, elastic tailoring concepts, buckling of composite structures. Prerequisites: AERSP 302, EMCH 471 or equivalent introductory course in composite materials.

597I - ***Spacecraft Environment Interactions***. (3) This course will examine various aspects of spacecraft aerodynamics and interactions with the space environment. The course will include some aspects of spacecraft design and the latest computational methods for calculating spacecraft aerodynamic forces and moments and thruster plume contamination.

AERSP 597J – ***Rotorcraft Stability and Control*** (3) Development of a set of general equations of motion of a rotorcraft in maneuvering flight. The generalized trim problem. Linearized equations of motion and stability derivatives. Stability and control analysis of rotorcraft. Rotorcraft flight simulation. Handling qualities analysis and automatic flight control design for rotorcraft.

597K - ***Small Scale Turbomachinery*** (3) Aero-thermo-mechanical Design of Small Gas Turbine Systems for Unmanned-Earial Vehicle (UAV) Systems.

597K - ***Elastic and Dynamic Stability*** (3) (ME 597K) Elements of structural dynamics and stability, buckling and snap-through elastic bodies, stability of gyroscopic continua, stability of dynamic systems. Prerequisites: AERSP 304 or ME 440 or equivalent introductory course in system dynamics, AERSP 597I or ME 552 also suggested.

600 Series – Graduate Level Research Courses

600 – Thesis Research – Credits used for M.Eng., M.S., and Ph.D.

601 – PhD Dissertation Full-Time – Ph.D. students will register for this 1-credit course the semester following the passing of the Oral Comprehensive Exam, and substantial completion of course requirements. (Students may also Audit one class when registered for 601.)

610 – Thesis Research Off-Campus – Used to complete thesis when student is no longer on campus.

611 – PhD Dissertation Part-Time – Used to complete dissertation when student is no longer a full-time student.

III ACADEMIC REQUIREMENTS & GUIDELINES

Graduate School Requirements

A detailed discussion of these requirements can be found in the Bulletin. All graduate students are urged to familiarize themselves with these requirements, particularly those relating to:

- Registration Worksheet located at
  http://www.psu.edu/registrar/forms_for_students/fallspringreg.pdf
- Registering for courses (different methods and instructions located at
  http://www.psu.edu/registrar/registration/methods_registration.html#A)
- Completing your registration (instructions located at
  http://www.psu.edu/registrar/registration/reg_instructions.html#A)
  Please remember that if you are on an assistantship you will need to write "Assistantship" on the semester bill and return it to the Bursar's office.
- Credit Loads including Thesis
- Candidacy Examination
- English Competency
- Comprehensive Examination
- Final Oral Examination
  Residency Requirement (http://www.gradsch.psu.edu/about/offcampus.html)
  Reclassification to PA Resident (http://www.psu.edu/bulletins/ltest/intro/gi-051.htm)

Departmental Requirements

The Department offers courses of study leading to three graduate degrees in Aerospace Engineering: the M.Eng., the M.S., and the Ph.D.

The M.Eng. is a non-thesis professional master's degree. It is usually a terminal degree for students who intend to pursue careers that do not emphasize research and development. However, it is sometimes obtained by highly qualified students who wish to accelerate progress towards a Ph.D. degree.

The M.S. is a thesis-based master's degree having a significant research component. It may be a terminal degree for students who intend to pursue research-related careers, or it may be a stepping-stone enroute to a Ph.D. degree.

The Ph.D. is a thesis-based doctor's degree. It is very strongly research-oriented and is a terminal degree for students who intend to pursue careers in research and development, research management, or university teaching.

Supervision and Advising

Students are under the general supervision of their advisors. (See policy below concerning the assignment of an advisor.) All coursework for which the student registers for credit must be approved by the advisor. The following forms are to be used for this purpose:

- Graduate Degree Semester Plan Approval Form (See Appendix B)
- Graduate Degree Program Plan Approval Form (See Appendix B)

The first form must be submitted to the advisor for approval each semester prior to the start of the semester in question. The second form shows the entire program of the student and should be updated periodically.

The policy for assignment of advisors is as follows:

- Each new student is assigned an advisor when he/she arrives.

- If a student is supported by research monies, then his/her advisor is **permanent** (i.e., advisors for Research Assistants and Research Aides are permanent).

- If a student is supported by non-research monies, i.e., departmental funds or any type of self-support such as private funds or fellowships, then his/her advisor initially is **temporary**. (i.e., advisors for Teaching Assistants, Teaching Aides, and students with government fellowships, etc. are temporary)

- Students with temporary advisors are encouraged to spend approximately two months meeting with Aerospace faculty before selecting a permanent advisor. Students should inform the Graduate Program Secretary upon the selection of a permanent advisor.

Academic Load

A graduate student who is not supported on an assistantship must register for a minimum of 9 credits to be considered full-time. A student wishing to take more than 15 credits in a semester must be granted an exception on an individual basis through the office of Graduate Student Programs.

Students on assistantships are encouraged to enroll in as many course credits, including thesis (600) that are permitted. The Department normally commits to assistantship funding for graduate students for the duration of their degree studies providing they are making satisfactory progress toward their degrees. **For M.S. or M.Eng degree candidates working as teaching assistants, the duration of this support is typically two years. Continued support for tuition, however, is only considered for students who have continuously enrolled in the recommended number of credits each semester** as summarized in Table 3.1. Additionally, **teaching assistants are strongly encouraged to seek a standard tuition waiver for summer semesters** in which to enroll in, and pursue thesis research. Please see the Graduate Program Secretary during the middle of the spring semester for details on how to apply for this.

Graduate assistants course and workloads are governed by the following table:

Table 3.1 Recommended Course Load for Graduate Assistants*

Level of Assistantship	Credits Per Semester		Credits per 8-Wk Summer Session		WorkHrs. Per Week
	Min.	Max.	Min.	Max.	
Quarter-time	9	14	5	7	10
Half-time	9	12	4	6	20
Three-quarter-time	6	8	3	5	30

"To provide for some flexibility, moderate exceptions to the specified limits may be made in particular cases with the approval of the student's program head and the dean of the Graduate School. The Graduate School expects that an exception made in one semester will be compensated for by a suitably modified credit load in the subsequent semester, so that, on the average, normal progress is maintained at a rate falling within the limits above. Failure to do so may jeopardize the student's academic status. **Maintenance of the established credit loads and responsibility for consequences of a graduate student's change of course load rest with the student and advisor**. The course load is a factor in determining whether a graduate student is classified as a full-time or part-time student; has met residence requirements; and is eligible to hold a fellowship, traineeship, assistantship, or departmental or program appointment."

"Graduate assistants whose credit loads equal or exceed the minima indicated in the table, and whose assistantship activities are directly related to their degree objectives, are considered by the Graduate School to be engaged in full-time academic work."

Credit loads for Internationals – The Immigration and Naturalization Services (INS) requires that international students proceed in a timely fashion toward completion of their degree, as established by the academic department and (usually) stated on their initial immigration document. Failure to maintain normal progress toward completion of the degree during this period will jeopardize the student's ability to continue academic study, adjust status or seek future employment in the United States. Because of this, students should not be enrolled less than full-time during fall or spring semester without approval of the Office of International Students and Scholars (OISS) 410 Boucke Building. (Less-than-full time form needs to be completed by student's advisor and returned to ISS for review and approval prior to the beginning of the semester requested.)

M.Eng. Degree

- A total of at least 30 credits is required for the M.Eng. degree
  - A scholarly paper (2 credits of AERSP 596)
  - A graduate seminar (1 credit of AERSP 590)
  - Other course credits—minimum of 27

- Restrictions on course credits
  - Maximum of 6 credits at 400-level
  - Minimum of 21 credits of aerospace courses
    - At least 18 credits of these must be at 500-level (including the credits for the seminar and the scholarly paper) (Exceptions can be made by advance petition and approval.)

- Core course requirements

Basic Field Theories (complete one in each of two different categories) (6 credits)
Fluid Mechanics: AERSP 508
System Dynamics: AERSP 518 AERSP 550 AERSP 553 EMch 520 PHYS 530
Solid Mechanics: AERSP 505 AERSP 553 AERSP 597F EMch 500 EMch 507 EMch 540
(Other courses may be substituted by advance arrangement.)

Numerical/Computational Methods (3 credits)
AERSP 423 AERSP 526 AERSP 527 AERSP 528 AERSP 529 AERSP 560 AERSP 597B
AERSP 597D ABE 513 CE 541 EMch 560
MATH 550 MATH 551 MATH 552 MATH 553 MATH 555 MATH 556

Applied Mathematics (3 credits)
EMch 524A EMch 524B EMch 550 PHYS 525
MATH 505 MATH 507 MATH 508 MATH 509 MATH 510 MATH 511 MATH 512 MATH 513
MATH 514 MATH 597K
(Other courses may be substituted by advance arrangement.)

AERSP 596 (2 credits)

AERSP 590 (1 credit)

- Other requirements
  - ENGR 588 (for TAs and TAides)
  - Thesis paper

Minimum grade point average from completion of all graduate degrees is 3.00

All courses used to satisfy degree requirements must be technical in nature, i.e. engineering, mathematics, or physical sciences.

Program requires a minimum of 30 credits in order to graduate.

Student may use a maximum of 6 credits of 400-level courses.

Self-supported or fellowship students who register for at least 9 credits are considered to be engaged in full-time academic work for that semester. If such a student wishes to register for more than 15 credits, an exception to the normal maximum load must be granted through petition (with advisor's approval) to the Office of Graduate Enrollment Services.

Students with a half-time assistantship need to register for 12 credits, typically 9 credits of course work and 3 credits of research.

Credit loads for Internationals – The Immigration and Naturalization Services (INS) requires that international students proceed in a timely fashion toward completion of their degree, as established by the academic department and (usually) stated on their initial immigration document. Failure to maintain normal progress toward completion of the degree during this period will jeopardize the student's ability to continue academic study, adjust status or seek future employment in the United States. Because of this, students should not be enrolled less than full-time during fall or spring semester without approval of the Office of International Students and Scholars (OISS) 410 Boucke Building. (Less-than-full time form needs to be completed by student's advisor and returned to ISS for review and approval prior to the beginning of the semester requested.)

The Department of Aerospace Engineering frequently supports M.S. and M.Eng. students as Teaching Assistants (TA). Our practice is to provide such Teaching Assistant support for three (3) semesters, followed by one (1) semester of support as a Teaching Aide. The Teaching Aide is a wage payroll position.

A Teaching Aide position provides students with support equivalent to that of the Teaching Assistant stipend and health benefit, with reduced support for tuition. Thus, students are expected to substantially complete their course requirements in the first three semesters; this involves enrolling for approximately 10-12 credits per semester.

Students may want to apply for the Tuition Assistance Program in the Summer Session 2004 to maximize tuition monies.

A bound copy of the Master's Paper is required for the Department.

TIME LIMITATION: All requirements for a master's degree (including acceptance of a thesis, paper, or project report as may be specified), whether satisfied on the University Park campus or elsewhere, must be met within eight years of admission to degree status. Individual programs may set shorter time limits. Extensions may be granted by the Director of Graduate Enrollment Services in appropriate circumstances.

*Information obtained from Graduate Degree Program Bulletin accessed at http://www.gradsch.psu.edu/bulletin/

M.S. Degree

- A total of at least 30 credits is required for the M.S. Degree
    - Thesis credits - minimum of 6
    - Course credits - minimum of 24

- Satisfactory completion of a M.S. thesis is required for graduation.

- Restrictions on course credits
    - Maximum of 6 credits at 400-level
    - Minimum of 6 credits of 500-level aerospace courses
    - Minimum of 12 credits of aerospace courses
    - Core course requirements - see below

- Core course requirements

Basic Field Theory (complete one in each of two different categories) (6 credits)
Fluid Mechanics: AERSP 508
System Dynamics: AERSP 518 AERSP 550 AERSP 553 EMch 520 PHYS 530
Solid Mechanics: AERSP 505 AERSP 553 AERSP 597F EMch 500 EMch 507 EMch 540
(Other courses may be substituted by advance arrangement.)

Numerical/Computational Methods (3 credits)
AERSP 423 AERSP 526 AERSP 527 AERSP 528 AERSP 529 AERSP 560 AERSP 597B
AERSP 597D ABE 513 CE 541 EMch 560
MATH 550 MATH 551 MATH 552 MATH 553 MATH 555 MATH 556

Applied Mathematics (3 credits)
EMch 524A EMch 524B EMch 550 PHYS 525
MATH 505 MATH 507 MATH 508 MATH 509 MATH 510 MATH 511 MATH 512 MATH 513
MATH 514 MATH 597K
(Other courses may be substituted by advance arrangement.)

- Other requirements
    - ENGR 588 (for TAs and TAides)
    - Thesis seminar
    - Give hard-bound copy of thesis to Department

Minimum grade point average from completion of all graduate degrees is 3.00

All courses used to satisfy degree requirements must be technical in nature, i.e. engineering, mathematics, or physical sciences.

Program requires a minimum of 30 credits in order to graduate.

Student may use a maximum of 6 credits of 400-level courses.

Self-supported or fellowship students who register for at least 9 credits are considered to be engaged in full-time academic work for that semester. If such a student wishes to register for more than 15 credits, an exception to the normal maximum load must be granted through petition (with advisor's approval) to the Office of Graduate Enrollment Services.

Students with assistantships should register for 12 credits, 9 credits of classes and 3 credits of research.

Credit loads for Internationals – The Immigration and Naturalization Services (INS) requires that international students proceed in a timely fashion toward completion of their degree, as established by the academic department and (usually) stated on their initial immigration document. Failure to maintain normal progress toward completion of the degree during this period will jeopardize the student's ability to continue academic study, adjust status or seek future employment in the United States. Because of this, students should not be enrolled less than full-time during fall or spring semester without approval of the Office of International Students and Scholars (OISS) 410 Boucke Building. (Less-than-full time form needs to be completed by student's advisor and returned to ISS for review and approval prior to the beginning of the semester requested.)

The Department of Aerospace Engineering frequently supports M.S. and M.Eng. students as Teaching Assistants (TA). Our practice is to provide such Teaching Assistant support for three (3) semesters, followed by one (1) semester of support as a Teaching Aide. The Teaching Aide is a wage payroll position.

A Teaching Aide position provides students with support equivalent to that of the Teaching Assistant stipend and health benefit, with reduced support for tuition. Thus, students are expected to substantially complete their course requirements in the first three semesters; this involves enrolling for approximately 10-12 credits per semester.

Students may want to apply for the Tuition Assistance Program in the Summer Session 2004 to maximize tuition monies.

Student will need to present their thesis at a public forum. Please provide an abstract of your thesis, along with the date, and time you would like to present at least two weeks prior to presenting to Graduate Program Staff Assistant.

A hard bound copy of your thesis is required for the Department.

TIME LIMITATION: All requirements for a master's degree (including acceptance of a thesis, paper, or project report as may be specified), whether satisfied on the University Park campus or elsewhere, must be met within eight years of admission to degree status. Individual programs may set shorter time limits. Extensions may be granted by the Director of Graduate Enrollment Services in appropriate circumstances.

*Information obtained from Graduate Degree Program Bulletin accessed at http://www.gradsch.psu.edu/bulletin/

Ph.D. Degree Requirements

Doctoral students must satisfy the Core Requirements. Graduate course requirements in addition to those specified in the Core Requirements are set by the candidate's doctoral committee on an individual basis. In general, there is no specified number of credits for the Ph.D. degree; however, students typically take at least 24 course credits beyond the M.S. degree. The doctoral thesis will involve research activity normally exceeding one full year of full time graduate work equivalent to 30 credits; exact requirements are determined by a student's doctoral committee. The minimum GPA for completion of the Ph.D. degree is 3.00.

- Core course requirements

Basic Field Theory (complete one in each of two different categories) (6 credits)
Fluid Mechanics: AERSP 508
System Dynamics: AERSP 518 AERSP 550 AERSP 553 EMch 520 PHYS 530
Solid Mechanics: AERSP 505 AERSP 553 AERSP 597F EMch 500 EMch 507 EMch 540
(Other courses may be substituted by advance arrangement)

Numerical/Computational Methods (3 credits)
AERSP 423 AERSP 526 AERSP 527 AERSP 528 AERSP 529 AERSP 560 AERSP 597B
AERSP 597D ABE 513 CE 541 EMch 560
MATH 550 MATH 551 MATH 552 MATH 553 MATH 555 MATH 556

Applied Mathematics (3 credits)
EMch 524A EMch 524B EMch 550 PHYS 525
MATH 505 MATH 507 MATH 508 MATH 509 MATH 510 MATH 511 MATH 512 MATH 513
MATH 514 MATH 580
(Other courses may be substituted by advance arrangement)

Experimental Requirement: (Do **one** of the following)

- Perform thesis research having an experimental component.
- Serve as TA for AERSP 405W or 406W.
- Take a course that emphasizes laboratory measurements, such as AERSP 420, ME 530, ME 536, ME 544, EMch 506, EMch 528, or ACS 505.
- Perform independent study (1 credit AERSP 596) by arrangement by your advisor. This could involve assisting another graduate student with experimental measurements, supervising an undergraduate laboratory project, or another activity.

- Other requirements
  - ENGR 588 (for TAs and TAides)
  - Dissertation

In addition to the aforementioned requirements, doctoral students must satisfy the following Graduate School requirements:

- Candidacy Exam □
- Formation of Doctoral Committee □
- English Competency □
- Comprehensive Examination □
- Final Defense of Thesis □
- Residence Requirement
- Continuous Registration

These are discussed in the Bulletin. Implementation procedures within the Department, where appropriate, are discussed on the following pages.

□Candidacy Examination

In Aerospace Engineering, the Candidacy Examination is given each Fall and Spring Semester within the first two months of the semester. Each Ph.D. program enrollee is required to take the examination during his or her <u>second</u> semester following enrollment; however, those who have been out of an academic environment for a year or more immediately preceding their enrollment may petition for a one-semester delay in taking the examination.

PH.D. CANDIDACY EXAM INFORMATION

	Fall 2003		Spring 2004
Date:	September 27, 2003	Date:	February, 7, 2004
Location:	220 Hammond Building	Location:	220 Hammond Building
Schedule:	9 am – 3 pm	Schedule:	9 am – 3 pm

PLEASE NOTE:
The following candidacy exam problems (without solutions) are now available for all interested students:

Fall 1990 thru Spring 2003

Students who wish to receive copies of the problems may do so from the Graduate Program Staff Assistant.

DESCRIPTION OF CANDIDACY EXAM
(POLICY G5)

Ph.D. CANDIDACY EXAMINATION
(Revised format – July 1996)*

PURPOSE
The Ph.D. candidacy examination is intended to provide an additional measure (beyond what can be determined from the admissions documents) of a student's preparation for doctoral work. This is particularly useful for a student whose earlier degrees were obtained in non-aerospace engineering programs and/or from other institutions. To be successful in a Ph.D. program, students must understand a range of subjects beyond the particular topic of their thesis research; hence, the candidacy exam should assess breadth of knowledge, posing questions from the primary fields that constitute our discipline: dynamics, fluids, mathematics, and structures. The exam does not require mastery of all four fields, but instead allows the student some choice in demonstrating a sufficient level of understanding in several areas.

FORMAT

Faculty will prepare three questions in each of the four subject areas, following the respective syllabus (see Appendix). Each problem is to be appropriate for a senior-level undergraduate or introductory-level graduate treatment of the subject. The exam is closed book, except for formulas provided with the examination questions.

A student taking the exam must attempt any eight of the twelve problems; the time limit for the exam is six hours. As a guideline, a passing grade is 75%, based upon the sum of all eight grades.

ADMINISTRATION

A student intending to pursue a Ph.D. in aerospace engineering should normally take the candidacy exam no later than the second semester of enrollment after admission to the Ph.D. program. Exceptions to this policy require a written petition to the Director of Graduate Academic Affairs. Anyone who wishes to take the candidacy examination must submit written notification, including an endorsement from his/her advisor, to the Director of Graduate Academic Affairs.

The Director of Graduate Studies will form four committees, giving each the responsibility to: 1) generate three problems, with solutions, and 2) carefully check the problems for clarity and appropriate level of difficulty.

Following the exam, two faculty will grade each problem on a scale of 1 to 10, and average their scores to give a single grade for that problem. If the two scores differ by more than 2 points, the Director will ask them to confer and attempt to resolve the difference; if that is not possible, a third member will be asked to grade the problem and that score will be averaged with the other two.

The departmental faculty will then meet to review the grades and determine the outcomes. A student who fails the exam on the first attempt is allowed to take the subsequent exam (typically offered near the beginning of each semester). In the event of a second failure, a student is then removed from the Ph.D. program. If there are extenuating circumstances, a student who fails the exam twice may petition the Graduate Academic Committee in writing for an oral candidacy examination. If the petition is granted, the Director of Graduate Studies will form a committee of three faculty to administer the oral exam and request that they make a recommendation of "pass" or "fail;" the Graduate Committee will then make the final decision.

*NOTE: The July 1996 Revised format replaces Aerospace Engineering Policy No. G5

Ph.D. Candidacy Exam
Fluids Syllabus

CONTROL VOLUME ANALYSIS
- Continuity, momentum and energy equations, applications

DIFFERENTIAL ANALYSIS OF FLUID MOTION
- Kinematics
- Rotation, vorticity, circulation
- Continuity equation
- Navier-Stokes equations

INCOMPRESSIBLE INVISCID FLOW
- Euler equations
- Bernoulli equation
- Velocity potential and stream function
- Elementary flows
- Forces and moments acting on a body
- Thin airfoil theory
- Lifting-line theory
- Slender-body theory

DIMENSIONAL ANALYSIS AND SIMILITUDE
- Application to problems in aerodynamics, hydrodynamics, rotating machinery, etc.

INCOMPRESSIBLE LAMINAR AND TURBULENT FLOWS
- Exact solutions of the Navier-Stokes equations
- Laminar and turbulent pipe flow
- Blasius boundary layer solution
- Integral methods for laminar turbulent boundary layers
- Similarity analysis of laminar and turbulent boundary layers
- Laminar jets and wakes
- Eddy viscosity and mixing length concepts
- Reynolds averaged equations

COMPRESSIBLE FLOWS
- Thermodynamics
- One-dimensional compressible flow
- Speed of sound and Mach number
- Alternative forms of the one-dimensional energy equation
- Stagnation, static and critical quantities
- Normal and oblique shock relations, shock polar
- Hugoniot equation
- One-dimensional flow with heat addition
- One-dimensional flow with friction
- Supersonic flow over wedges
- Prandtl-Meyer expansions
- Prandtl-Glauert equation
- Linearized theory for thin airfoils
- Full potential equation

SUGGESTED REFERENCES:

1. White, F.W., *Fluid Mechanics*, 2nd edition, McGraw-Hill, 1989.

2. Anderson, J.D., *Modern Compressible Flows, with Historical Perspective*, 2nd ed., Wiley, 1994.

3. Anderson, J.D., *Fundamentals of Aerodynamics*, 2nd ed., McGraw-Hill, 1991.

4. Munson, B.R., Young, D.F., Okiishi, T.H., *Fundamentals of Fluid Dynamics*, 2nd ed., Wiley, 1994.

(Note: given some duplication of material in these references, students need to review them all, but they are also encouraged to consult sources in addition to those listed here.)

Ph.D. Candidacy Exam
Structures Syllabus

STRESS AND STRAIN

- Definitions
- Differential equations of stress equilibrium
- Stress transformation under coordinate change, principal stresses, and maximum shear stresses
- Linear strain-displacement relation; tensor vs. engineering strains; compatibility equations
- Strain transformation, principal strains, and maximum shear strains
- Strain measurement using strain gages

MATERIAL BEHAVIOR

- Linearly elastic constitutive relations; isotropic, orthotropic
- Yield and failure theories; Von Mises and Tresca criteria
- Fatigue

THEORY OF SIMPLE STRUCTURAL MEMBERS (RODS, BEAMS, SHAFTS)

- Kinematic assumptions (e.g., Bernoulli-Euler beam)
- Differential equations of equilibrium; displacement and force boundary conditions
- Principle of superposition; St. Venant's principle
- Extension (displacements, strains, stresses)
  - Stress concentration (plane stress)
  - Extensional rigidity
- Bending (displacements, strains, stresses)
  - Build-up ("composite") beams
  - Modulus-weighted centroid, neutral axis; flexural rigidity
- Torsion (displacements, strains, stresses)
  - Thin-walled open sections; thin-walled open sections; thin-walled multi-cell closed sections
  - Shear flow
  - Shear center, elastic axis; torsional rigidity
- Transverse shear (displacements, strains, stresses)
  - Thin-walled sections

ENERGY METHODS

- Work and potential; strain energy; kinetic energy
- Principle of virtual work; Principle of stationary total potential energy
- Ritz method
- Complementary potential energy; Castigliano's theorems; Unit Load method

FINITE ELEMENT METHOD

- Truss and beam elements; nodal degrees of freedom; displacement functions
- Strain energy; potential or virtual work of applied loads
- Element stiffness matrices, load vectors associated with distributed loads
- Element-to-global coordinate transformation
- Assembly of global stiffness matrix and load vector; enforcing boundary conditions
- Recovery of element forces, stresses, and strains; reaction forces

ELASTIC STABILITY

- Concept of stability
- Overall column buckling; effects of end conditions, length, flexural rigidity
- Effects of initial imperfections or load eccentricity
- Buckling of rectangular plates under in-plane loads

SUGGESTED REFERENCES:

1. Donaldson, B.K., *Analysis of Aircraft Structures, An Introduction*, McGraw-Hill, 1993.

2. Allen, D.H. and Haisler, W.E., *Introduction of Aerospace Structural Analysis*, John Wiley & Sons, 1985.

3. Cook, R.D. and Young, W.C., *Advanced Mechanics of Materials*, Macmillan, 1985.

(Note: given some duplication of material in these references, students need not review them all, but they are also encouraged to consult sources in addition to those listed here.)

Ph.D. Candidacy Exam
Dynamics Syllabus

KINEMATICS
- Orthogonal coordinate systems and transformations
  - Cartesian, cylindrical, spherical systems
- Motion in inertial and accelerating reference frames
  - Rectilinear/curvilinear velocities and accelerations; Coriolis acceleration

MOMENTUM AND IMPULSE
- Momentum and impulse – linear and angular
- Newton's laws and D'Alembert's principle

WORK AND ENERGY PRINCIPLES
- Hamilton's principle
- Lagrange's equations

PARTICLE MECHANICS
- Particle dynamics in a uniform gravitational field
- Elementary orbital mechanics

RIGID-BODY DYNAMICS
- Inertia tensor
- Euler's equations
- Torque-free motion
- Gyroscopic devices

VIBRATION AND STRUCTURAL DYNAMICS
- Lump-parameter systems
  - Single and multiple DOF discrete systems
  - Algebraic eigenvalue problem; natural frequencies and mode shapes
  - Forced response of damped systems
- Distributed-parameter systems (structures)
  - Wave equation for rods; equation of motion for transverse vibration of beams
  - Eigenvalue boundary value problem; natural frequencies and mode shapes
  - Kinetic energy
  - Rayleigh-Ritz method
  - Modal superposition for forced response of damped structure

SUGGESTED REFERENCES:

1. Greenwood, D.T., Principles of Dynamics, 2nd ed., Prentice-Hall, 1988.

2. Marion, J.B. and Thornton, S.T., *Classical Dynamics of Particles and Systems*, 4th ed., Saunders College Pub., 1995.

3. Thornson, W.T., *Vibration Theory and Applications*, 4th ed., Prentice-hall, 1993.

(Note: given some duplication of material in these references, students need not review them all, but they are also encouraged to consult sources in addition to those listed here.)

Ph.D. Candidacy Exam
Mathematics Syllabus

ORDINARY DIFFERENTIAL EQUATIONS
- First- and second-order equations
- Homogeneous and inhomogeneous equations
- Systems of ordinary differential equations
- Elementary Laplace transforms
- Series solutions
- Sturm-Liouville equation

PARTIAL DIFFERENTIAL EQUATIONS
- Classification of equations
- Separable solutions
- Boundary and initial value problems
- Green functions
- Similarity solutions
- Characteristics

VECTOR CALCULUS
- Scalars and Vectors
- Dot and cross products
- Conformal mapping
- Evaluation of line integrals
- Method of residues
- Evaluation of real integrals

FOURIER SERIES

FOURIER AND LAPLACE TRANSFORMS
- Inverse Laplace transforms

LINEAR ALGEBRA
- Matrix operations
- Eigenvalues and eigenvectors
- Gaussian elimination
- LU factorization

NUMERICAL ANALYSIS
- Interpolation and root finding
- Numerical integration
- Finite difference approximations
- Solution of ordinary differential equations
- Solution of partial differential equations

SPECIAL FUNCTIONS
- Bessel and Hankel functions
- Legendre and Chebyshev polynomials

SUGGESTED REFERENCES:

1. Kreyszig, E. Advanced Engineering Mathematics, 7th ed., John Wiley & Sons, 1993.

2. Arfken, G.B., Mathematical Methods for Physicists, 3rd ed., Academic Press, 1985.

3. Wylie, C.R., and Barrett, L.C., Advanced Engineering Mathematics, 6th ed., McGraw-Hill, 1995.

(Note: given some duplication of material in these references, students need not review them all, but they are also encouraged to consult sources in addition to those listed here.)

Doctoral Committee

Following admission to candidacy, the Ph.D. student should promptly initiate formation of his or her doctoral committee. Selection of the members is the joint responsibility of the student and his or her thesis advisor subject to approval by the Department Head. The "Graduate Student Committee Policies and Procedures and Committee Appointment Signature Page," can be obtained from the Graduate Program Secretary and, when completed, will need to be approved by the Director of Graduate Studies. This form is necessary to initiate paperwork for formal appointment of the members by the Graduate School.

English Competency

The Graduate School requires a formal assessment of reading, writing, and speaking abilities in English for all Ph.D. students.

The Department of Aerospace Engineering implements the Graduate School English Proficiency Policy by focusing on the attainment of English proficiency as an important component of the development of student research skills. The Department's plan requires demonstration of high-level competence in the use of the English language, including reading, writing, and speaking. Please inform the Graduate Program Staff Assistant, at least one week in advance, of the date, time and place of the exam.

Initial Assessment of English Proficiency

The goal of the initial stage of assessment is to identify those students having serious deficiencies in their command of the English language. Upon entering the Ph.D. program, students normally meet with numerous departmental faculty, including the Department Head, the Director of Graduate Studies, and several potential faculty advisors. Each of these people has ample opportunity to informally assess student competence in English. It is the responsibility of the student's academic advisor to identify serious deficiencies and to recommend an immediate course of action. Recommended courses include ESL 114G-118G. The earlier a student attains English competency, the more effectively he or she can concentrate on developing research capabilities. The advisor will continue monitoring progress in this regard until the student passes the written (technical) candidacy examination.

English Proficiency Exam

Upon passing the candidacy exam, a student's faculty advisor will consult with the Director of Graduate Studies and initiate the constitution of a Doctoral Committee. The committee should be convened as soon as practical (normally within a semester upon passing the candidacy) to establish general student research direction and specific coursework requirements. As a natural part of this process, the committee will formally assess the student's English proficiency. The goal at this stage is to identify students having significant deficiencies in their command of English. In addition to informal discussions, the assessment will consist of the following elements:

(1) **Reading**. In consultation with the faculty advisor, the student will identify several publications pertinent to the contemplated research project. The student will then read and summarize the contents of these publications in both the written thesis proposal and its oral presentation.

(2) **Writing**. The student will prepare a preliminary research proposal at least 5 pages in length, including a tentative plan for Ph.D. coursework, and distribute it to the committee members for advance review. Faculty will evaluate it on the basis of logical organization, clarity, correct English usage, and technical content. A short expository writing assignment may be required in addition, at faculty discretion.

(3) **Speaking**. The student will prepare and make a presentation at least 20 minutes in length to the committee on the subject of the thesis proposal. The student will respond to questions following the presentation. Faculty will evaluate the presentation on the basis of logical organization, clarity, correct English usage, and technical content.

Upon completion of the first meeting, the committee will report on the student's English competency in three areas: reading, writing, and speaking.. If no significant deficiencies are noted, the committee will attest to satisfaction of the Graduate School requirement. (Please inform the Graduate Program Staff Assistant at least one week in advance of the exam of the date and time. (The student does not need to be registered for classes when this exam is taken.)

Enhancement of English Competency

If, in the opinion of the majority of the committee members, significant deficiencies exist in any of the areas, the student will be required to enroll in appropriate remedial courses (from the following list). (Reading: ESL 116G. Writing: ESL 116G, ENGL 202C, ENGL 198G, ENGL 418. Speaking: ESL 114G, ESL 115G. Presenting: ESL 100A, ESL 312.) Attainment of a grade of "B" or better will be taken to constitute satisfactory completion of the corresponding requirement.

Comprehensive Exam

When a Ph.D. candidate has substantially completed all course work, a comprehensive examination is given. This exam is intended to evaluate the candidate's mastery of the major (and if appropriate, minor) field(s). Before taking the "comps," a student must have satisfied the English competence requirement, must have a minimum GPA of 3.00, and must be registered. (If the exam will be taken during the summer, the student should apply for the Summer Tuition Assistance Program early in the preceding Spring semester.) The student's doctoral committee administers the exam.

In Aerospace Engineering, the doctoral committee may, at its discretion, require the candidate to complete one or more written problems in advance of the oral exam. During the oral part of the comprehensive exam, the candidate typically presents a proposal for Ph.D. dissertation research, including a literature review (if that was not covered as part of the English proficiency exam), objectives, approach, preliminary results, and a plan for completion. A nominal duration for the presentation is 30-40 minutes. Following that presentation, the committee may pose questions regarding written problems (if any), the proposed research topic, and the general preparation of the candidate to pursue Ph.D. research. A favorable vote of at least two-thirds of the members of the committee is required for passing. In case of failure, it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. Once the comprehensive exam has been passed, the student may register for AERSP 601 (reduced tuition) in subsequent semesters.

Please inform the Graduate Program Staff Assistant, at least three weeks in advance, of the date, time and place of the exam. Materials need to be processed by Graduate Enrollment Services and returned in time for the exam.

After a PhD candidate has passed the comprehensive examination and met the two-semester full-time residence requirement, the student must register continuously for each fall and spring semester, until the thesis is accepted and approved by the doctoral committee.

When a period of more than six years has elapsed between the passing of the comprehensive examination and the completion of the program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

Final Oral Examination ("Defense")

The final examination of the doctoral candidate is an oral examination administered and evaluated by the entire doctoral committee. It consists of an oral presentation of the thesis by the candidate and a period of questions and responses. Questions will relate in large part to the dissertation, but may cover the candidate's entire program of study, because a major purpose of the examination is also to assess the general scholarly attainments of the candidate. The portion of the examination in which the thesis is presented is open to the public.

Normally the final "defense" may not be scheduled until at least three months have elapsed after the comprehensive examination was passed; a more typical time is in excess of a year. A student must be registered in the semester during which the exam is taken. (If the exam will be taken during the summer, the student should apply for the Summer Tuition Assistance Program early in the preceding Spring semester.)

Both the thesis adviser and the student are responsible for ensuring the completion of a draft of the thesis *and for adequate consultation with members of the thesis committee well in advance of the oral examination. Major revisions to the thesis should be completed before this examination.* It is the responsibility of the doctoral candidate to provide a copy of the thesis to each member of the doctoral committee at least two weeks before the date of the defense. The dissertation should be in its final draft at the time of the oral examination; both the content and style should be correct and polished. A favorable vote of at least two-thirds of the members of the committee is required for passing. If a candidate fails, it is the responsibility of the doctoral committee to determine whether another examination may be taken.

Please inform the Graduate Program Staff Assistant at least three weeks in advance so that a room may be scheduled for the day and time requested and the needed paperwork obtained from Graduate Enrollment Services.

Please see the Graduate School requirements for additional information, at: http://www.psu.edu/bulletins/whitebook/$gradreqs.htm

Residence Requirement
There is no required minimum of credits or semesters of study, but over some twelve-month period during the interval between admission to the PhD program and completion of the PhD program the candidate must spend at least **two semesters** as a registered full-time student engaged in academic work at the University Park campus. Full-time University employees must be certified by the department as devoting half-time or more to graduate studies and/or thesis research to meet the degree requirements. (See Credit Loads and Academic Status in the Bulletin.)

Continuous Registration
It is expected that all graduate students will be properly registered at a credit level appropriate to their degree of activity. (See Registration.) After a PhD candidate has passed the comprehensive examination and met the two-semester full-time residence requirement, the student must register continuously for each fall and spring semester. (beginning with the first semester after both of the above requirements have been met) until the PhD thesis is accepted and approved by the doctoral committee. (Note that students whoa are in residence during summers must also register for summer sessions.)

Minimum grade point average from completion of all graduate degrees is 3.00

All courses used to satisfy degree requirements must be technical in nature, i.e. engineering, mathematics, or physical sciences.

Program requires satisfaction of core requirements in order to graduate.

Student may use a maximum of 6 credits of 400-level courses.

Self-supported or fellowship students who register for at least 9 credits are considered to be engaged in full-time academic work for that semester. If such a student wishes to register for more than 15 credits, an exception to the normal maximum load must be granted through petition (with advisor's approval) to the Office of Graduate Enrollment Services.

Students with half-time assistantships should register for 12 credits, typically 9 credits of classes and 3 credits of research.

Credit loads for Internationals - The Immigration and Naturalization Services (INS) requires that international students proceed in a timely fashion toward completion of their degree, as established by the academic department and (usually) stated on their initial immigration document. Failure to maintain normal progress toward completion of the degree during this period will jeopardize the student's ability to continue academic study, adjust status or seek future employment in the United States. Because of this, students should not be enrolled less than full-time during fall or spring semester without approval of the Office of International Students and Scholars (OISS) 410 Boucke Building. (The Less-Than-Full Time form needs to be completed by the student's advisor and returned to ISS for review and approval prior to the beginning of the semester requested.)

Students may want to apply for the Tuition Assistance Program in the Summer Session 2004 to maximize tuition monies.

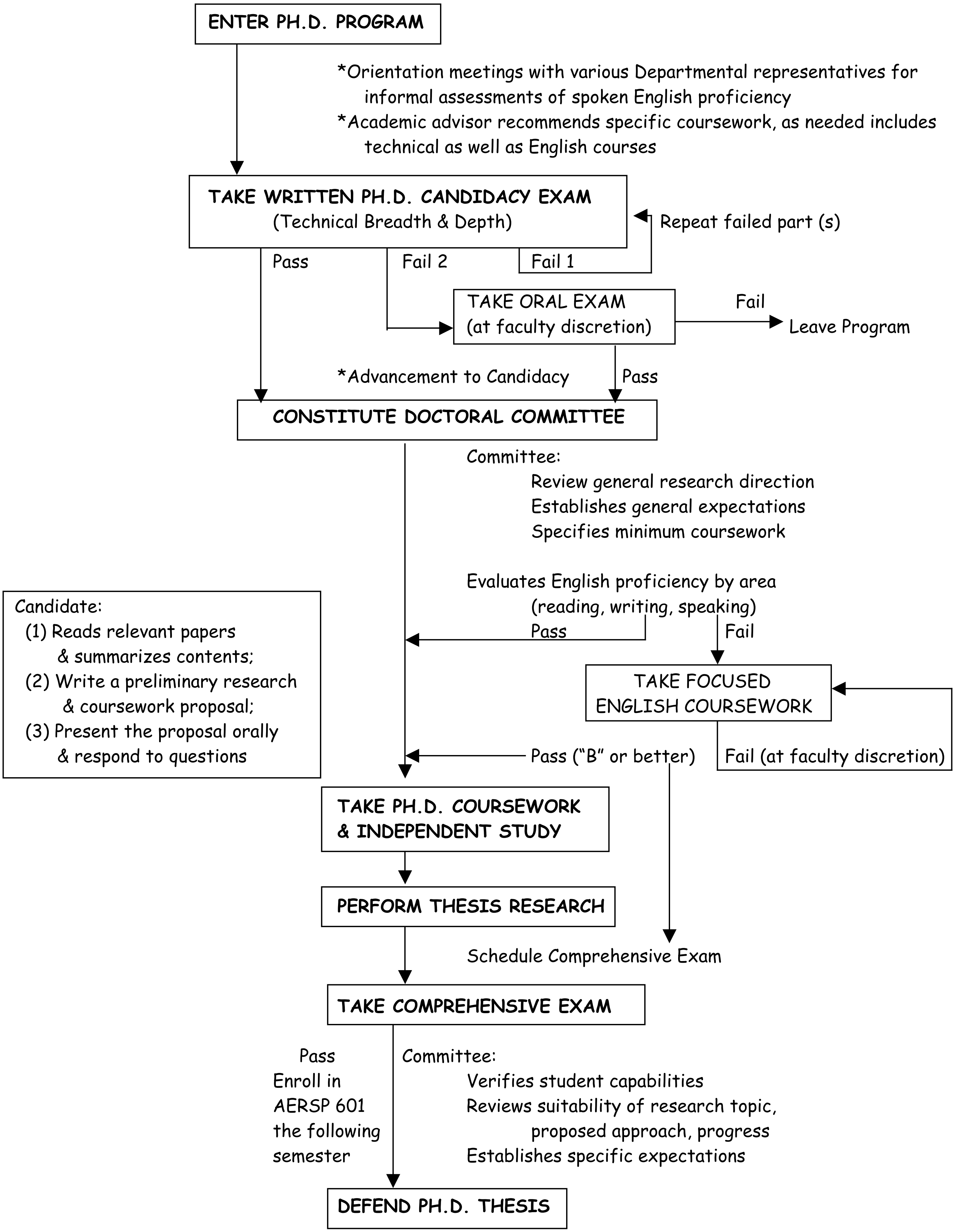
Six Step in the Ph.D. Program
1) Pass Candidacy Exam
2) Form Doctoral Committee
3) Internal English Proficiency Exam
4) Comprehensive Exam
5) Final Defense
6) Turn in bound hard copies of dissertation

A hardbound copy of your thesis is required for the Department.

TIME LIMITATION: All requirements for a doctoral degree (including acceptance of a thesis, paper, or project report as may be specified), whether satisfied on the University Park campus or elsewhere, must be met within eight years from the date of successful completion of the candidacy examination. Individual programs may set shorter time limits. Extensions may be granted by the Director of Graduate Enrollment Services in appropriate circumstances.

*Information obtained from Graduate Degree Program Bulletin accessed at http://www.gradsch.psu.edu/bulletin/

Ph.D. Flow Chart



IV. RESEARCH AREAS & FACILITIES

Primary Research Areas

As illustrated in the figure on the following page, the Department provides coursework and research projects in the following areas of emphasis: analytical/computational fluid dynamics, aeroacoustics, experimental fluid dynamics, flight science and vehicle dynamics, dynamics and control, rotorcraft engineering, structural dynamics/structures and materials, space propulsion, and turbomachinery. Areas within these specializations include flow instabilities and turbulence, advanced airfoil design, rotorcraft dynamics, spacecraft dynamics, advanced composite structures, smart structures, advanced electric propulsion, and heat transfer.

Analytical / Computational Fluid Dynamics

Fast algorithms; grid generation; hypersonic flow; development of inverse design optimization methods; development of algorithms for massively parallel computers; turbulence; hydrodynamic stability; aeroacoustics; computations of large-scale turbulence structure in SCRAMJET combustors and in advanced nozzle designs; computations of various turbomachinery flowfields.

Aeroacoustics

Computational aeroacoustics (CAA) applied to jet noise, fan inlet noise, acoustic liners, broadband airfoil noise, acoustic scattering, and cavity noise; semi-analytic predictions of jet noise; experimental studies of supersonic jet noise and centrifugal fan noise.

Experimental Fluid Dynamics

Turbulence structure in supersonic shear layers and in swirling flows; development of turbulent vortical structures in boundary layers; hydrodynamic instabilities and turbulence; hydroacoustics of boundary layer transitions; aeroacoustics of supersonic jets.

Flight Science and Vehicle Dynamics

Analytical, computational and experimental programs in various areas including -aircraft design, performance, stability and control; airfoil design and analysis; low Reynolds number aerodynamics; wing-body aerodynamics, subsonic/hypersonic aerodynamics; aircraft operation; advanced concepts in V/STOL rotor control; propeller/stator interactions; rotorcraft aeromechanics.

Dynamics and Control

Spacecraft dynamics and control; astrodynamics; use of generalized perturbation methods for various problems of orbital motion.

Rotorcraft Engineering

Active control of rotor and drivetrain vibration and stability; modeling and characterization of elastomeric materials for dampers and bearings; dynamics of aeroelastically tailored helicopter and tiltrotor blades; computational aeroacoustics and aeroelasticity of rotors using parallel computers; dissimilar rotor systems for reduced vibration and noise; bearingless rotor optimization; rotorcraft health and usage monitoring.

Structural Dynamics / Structures and Materials

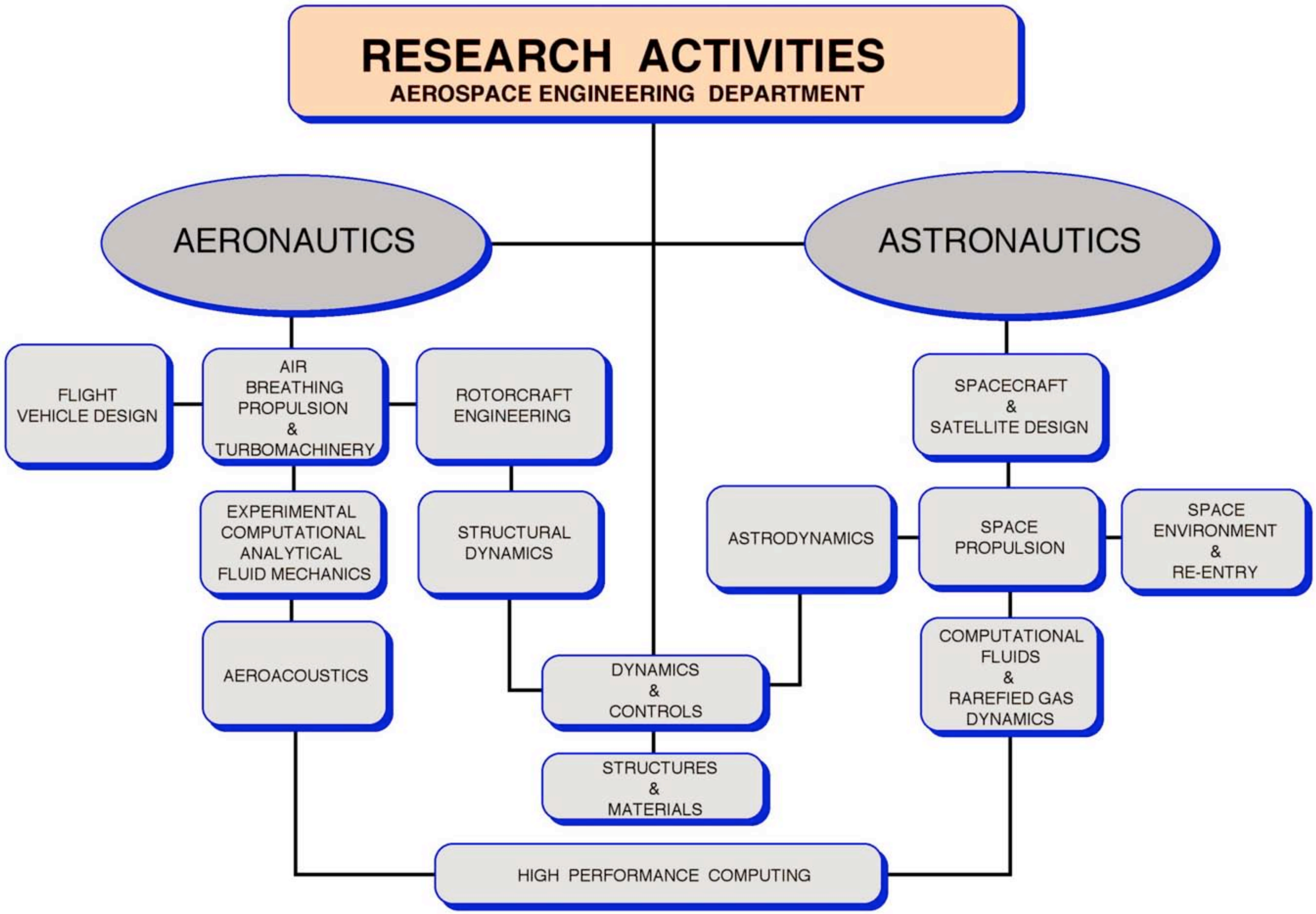
Analysis of flexible space structures; aeroelasticity problems in V/STOL aircraft; advanced composite materials; spacecraft dynamics and control; development of techniques for improved dynamic analysis of damped structures. Aerospace structures and advanced composite materials; experiments and analysis of filament wound composite structures; smart structures having embedded sensors and actuators.

Space Propulsion

Rocket propulsion; instabilities in solid propellant combustion; microwave-heated advanced propulsion concepts; Monte-Carlo computations of advanced inlet and nozzle designs.

Turbomachinery

Aerothermodynamics of turbomachinery; convective heat transfer; short duration wind tunnel techniques and fast response instrumentation; turbulent flow; turbulence modeling; computations and measurements of three-dimensional turbulent flow in compressors and turbine rotors; aeroacoustics of turbomachinery.


RESEARCH ACTIVITIES
AEROSPACE ENGINEERING DEPARTMENT
AERONAUTICS
ASTRONAUTICS
FLIGHT VEHICLE DESIGN
AIR BREATHING PROPULSION & TURBOMACHINERY
ROTORCRAFT ENGINEERING
EXPERIMENTAL COMPUTATIONAL ANALYTICAL FLUID MECHANICS
STRUCTURAL DYNAMICS
AEROACOUSTICS
DYNAMICS & CONTROLS
STRUCTURES & MATERIALS
SPACECRAFT & SATELLITE DESIGN
ASTRODYNAMICS
SPACE PROPULSION
SPACE ENVIRONMENT & RE-ENTRY
COMPUTATIONAL FLUIDS & RAREFIED GAS DYNAMICS
HIGH PERFORMANCE COMPUTING

Computational and Experimental Facilities

Computer Facilities

Penn State computer facilities available to aerospace engineering students include the 3-processor IBM 9000 vector computer (PSUVM), IBM RS/6000 workstations, X-terminals, Silicon Graphics workstations, and IBM-compatible personal computers. In addition, the computer center has a 61-node IBM SP2 computer for numerically intensive applications. Personal computers and mainframe terminals are available at all of the campus student computer labs.

Silicon Graphics and IBM RS/6000 workstations are located in the third floor of Hammond Building computer lab. The Aerospace Engineering Computer Lab, Room 51 and 136 Hammond Building, contains several IBM-compatible personal computers. Most of the computer labs are outfitted with laser printers. Accounts for using these computers are often established in various aerospace engineering classes. If you need accounts set up for the PC's or the door card reader for 51 and 136 Hammond Building, please see Mr. Mark Catalano, Department Computer/Electronics Coordinator. Mr. Catalano's office is located in Room 226 Hammond Building.

The Aerospace Engineering student computer lab has recently been upgraded with numerous computers and peripherals. Should you have difficulty getting a system to meet your needs, please see Mr. Catalano.

The Center for Academic Computing (CAC) regularly holds classes and/or information sessions on operating systems and popular systems and application software available on the various computer platforms. Information regarding the CAC and its services may be obtained from any of the campus student computer labs. Lab operators are often stationed in the computer labs to help with student computer needs. They are an excellent source of information if you have trouble with computer hardware/software, or just need information.

What follows is a summary list of popular software used by aerospace engineering students, grouped by type of application. This is not an all-inclusive list; rather, it is intended to give the student a feel for some of the software packages available for use. Detailed information on the software available can be obtained from the CAC, computer labs, or the lab operators. You could also use the world-wide web: http://cac.psu.edu/infotech/software.html.

Computer hardware and software can be purchased at the Penn State Computer Store (Willard Building) or the Penn State Bookstore.

Programming
Programming software is used to create your own programs, often to solve engineering problems. Various programming languages, including FORTRAN, C, C++, MATLAB, and BASIC are available on most computer platforms. Ready-to-use software libraries, such as IMSL, LINPACK, and EISPACK, are available for student use through the network, providing specific code addressing typical engineering problems.

Wordprocessing
Wordprocessing software can be used to write, edit, and print reports, letters, documents, resumes, and theses. Microsoft Word is available on the personal computers.

Spreadsheets
Spreadsheet software is essentially used for dealing with numerical data. Data can be manipulated, analyzed, and plotted in a spreadsheet program. EXCEL is a spreadsheet software package available on the personal computers.

Computer Aided Design (CAD)
Computer aided design (CAD) software allows the user to build and manipulate a structure on a computer. Some advanced CAD packages, such as Pro Engineer on the PCs perform static and dynamic structural analysis and optimization. A simpler, more straightforward CAD package is AutoCAD2000i, Solidworks Education edition, available on the personal computers in 51 Hammond Building.

Presentations
Presentation software can be used to create, edit, and print slide shows, handouts, and speeches. PowerPoint presentation software is available on the personal computers.

Math Software
Several math software packages are available to solve simple and complex mathematical problems. MathCAD is a symbolic math software processor. Matlab is available on the personal computers.

Software List on PCs in 51 Hammond

WINDOWS 2000 SP4
AUTOCAD 2000i
MS OFFICE 2000

- Word
- PowerPoint
- Access

MATLAB 6.0
VISUAL C++6.0
Norton Antivirus Corporate Editor
Satellite Tool Kit 5.0
PRO ENGINEER 20
EXCEED
SolidWorks Education Edition

Internet Access

- Netscape
- FTP
- Excel
- Telnet
- QWS 3270
- Utilities
- Internet Explorer

Experimental Facilities

Numerous wind tunnels
Low-turbulence subsonic wind-tunnel with six-component strain gauge balance (3.25 x 5 foot test section); low-turbulence boundary layer tunnel (2 x 3 feet test section); anechoic open jet wind tunnel (28” x 72” test section); supersonic free shear layer facility (2 x 5 inch test section); convective heat transfer tunnel with real-time color image processing; compressed air flow facility (300-psi reservoir); several probe calibration jets limited access to supersonic wind tunnel (6 x 6 inch test section).

Water channels/Water Tunnel
Laminar flow water channel (1.5 x 2.5 foot test section); limited access to the Garfield Thomas Water Tunnel of the Applied Research Laboratory.

Aeroacoustic facilities
A semi anechoic chamber and adjoining reverberation room. A large anechoic chamber with co-flow capability. A gas mixture and heated jet facility to simulate jet engine exhausts for aeroacoustic studies.

Structures research laboratory
A high temperature bi-axial tension/torsion testing facility; a fiberoptic interferometer; an ultrasonic inspection system; hydraulic testing machine

Composites materials laboratory
Autoclave (3 foot diameter x 7 foot length); a computer-controlled filament winding machine; a pultrusion machine; a braiding machine for composite materials manufacturing

Space propulsion facilities
High vacuum tank facility for low-density flow; unsteady propellant combustion facility; variable power microwave generator and propulsion facility; spectrometer and a CW Nd laser for space propulsion research

Several large turbomachinery facilities
Axial flow turbine; multi-stage compressor facility; linear turbine cascade facility; 6’ diameter rotor-rig.

Other experimental facilities include
Several laser Doppler anemometers including a subminiature semiconductor model; two partical image velocimeter systems; an ATC/510G flight simulator; a thermal analysis system; an acoustic emission system; reflection polariscope used in material fabrication and characterization

Duties for Department's Lab and Computer Coordinators

LABORATORY DIRECTOR

The Laboratory Director assists the Aerospace faculty, staff, and students as needed in all technical aspects of instructional, academic and research-related laboratory activities. This position is presently filled by Mr. Richard Auhl, located in 38A Hammond Building. His areas of responsibilities include but are not limited to the following:

- Assist the Department Head with the implementation of department management strategies, staff software training, information systems development and strategic planning.
- Assist the faculty with undergraduate laboratory course instruction. (AERSP 405W/406W)
- Coordinate the laboratory facility and department space allocation.
- Provide engineering and fabrication advice or assistance to faculty and students involved in project activity.
- Supervise the part-time laboratory assistants involved in general department maintenance.
- Serve as the primary contact person for the Dean's Office with regard to department space and facilities management.
- Coordinate and supervise all Machine Shop activities.
- Serve as the laboratory safety officer.

COMPUTER/ELECTRONICS COORDINATOR

The Computer/Electronics Coordinator assists the Aerospace faculty, staff, and students as needed in technical aspects of computer and general electronic systems. This position is currently filled by Mr. Mark Catalano, located in 226 Hammond Building. His primary responsibilities are listed below in order of their importance to the Department:

- Maintain and support all computer and network related equipment in the Department.
- Responsible for upgrading the hardware and software of all computers in Department.
- Provide purchasing support to Department on computer/electronic related equipment.
- Diagnose electronics problems as they arise and repair or replace equipment.
- Responsible for the installation of new electronic equipment in the Department.
- Responsible for maintaining the card reader system in computer lab.
- Provide classroom support for A/V equipment when student aid is not available.
- Supervise part-time students working in the electronic shop.

Please feel free to contact Mr. Auhl or Mr. Catalano if you have any questions concerning Department laboratory facilities.

Description of Faculty Research Interests

ROTORCRAFT ACOUSTICS, COMPUTATIONAL AEROACOUSTICS AND HIGH PERFORMANCE COMPUTING

Kenneth S. Brentner, Ph.D., University of Cambridge, U.K. ksbrentner@psu.edu

Research interests focus on rotorcraft and aircraft aeroacoustics, computational aeroacoustics, fluid mechanics, computational fluid dynamics, and high performance computing. Specific areas of research include rotor source noise prediction, prediction and characterization of rotorcraft noise in maneuvering flight, prediction of landing gear noise and other types of airframe noise. Recent research activities include the development of the rotorcraft noise prediction code PSU-WOPWOP which is able to predict noise from a rotorcraft with multiple rotors in both steady and maneuvering flight; prediction of noise generation and propagation from wind turbines; development of a component based landing gear noise prediction system; and investigation of soot combustion in underexpanded jet plume flows.

AEROTHERMODYNAMICS OF TURBOMACHINERY AND HEAT TRANSFER

Cengiz Camci, Ph.D., Von Karman Institute for Fluid Dynamics, Belgium c-camci@psu.edu

Research interests focus on studies in fluid mechanics and heat transfer in turbomachinery systems. Specific areas of research include aerodynamic loss generation mechanisms, secondary flows, endwall contouring, turbulent boundary layers, film cooling of high pressure turbine blades, turbine airfoil design, wall heat flux measurements in turbines, non-intrusive measurement techniques (Laser Doppler anemometry LDA and particle image velocimetry PIV) applied to rotating machinery and digital image processing of liquid crystal covered surfaces for basic heat transfer studies. Recent research activities include the investigation of radar antenna aerodynamics, turbine tip leakage reduction, tip cooling, turbine intra-stage coolant ejection, heat transfer studies using an image processing based liquid crystal technique, elliptical pin-fins, oscillating fins for internal cooling passages, tip heat transfer in a linear cascade, trailing edge coolant injection and the implementation of a stereoscopic PIV in the rotor of an axial flow turbine. A new facility for the aero-mechanical testing of helicopter main rotor blades including icing is under development. Large scale computation of three dimensional unsteady and turbulent flow systems including rotational effects is currently being performed using a 25 processor computer cluster.

HELICOPTER DYNAMICS AND AEROELASTICITY, SMART STRUCTURES

Farhan S. Gandhi, Ph.D., University of Maryland fgandhi@psu.edu

Research interests include the broad areas of helicopter dynamics and aeroelasticity, smart materials, and adaptive structures and systems. Specifically in helicopters, Dr. Gandhi's research has focused on use of passive design optimization, semi-active, and active control for helicopter and tiltrotor aeroelastic and aeromechanical stability augmentation, vibration reduction, and blade-vortex interaction alleviation. Dr. Gandhi also has a strong interest in advanced configurations and concepts including swashplateless helicopters and unmanned and micro aerial vehicles. In the area of smart materials and structures, Dr. Gandhi has experience with piezoelectric actuation systems, shape memory alloys, electro- and magneto-rheological fluids, and active constrained layer damping treatments. His interests are in using smart materials for structural morphing (particularly aircraft morphing) and structural vibration reduction and damping augmentation. Recent interests also include bio-inspired structures and actuation systems.

FLIGHT MECHANICS AND CONTROL

Joseph F. Horn, Ph.D., Georgia Institute of Technology joehorn@psu.edu

General research interests are in the areas of flight dynamics, automatic flight control systems, guidance and navigation, handling qualities, and flight simulation and modeling. Current research activities have focused on control system design and flight simulation for rotorcraft and rotorcraft UAV applications. Specific research topics include envelope protection systems, damage mitigating control, nonlinear adaptive control, integration of flight controls and health and usage monitoring systems, control design for compound helicopters, simulation and control of helicopter shipboard operations, autonomous control of UAV's, and coupled flight dynamics and acoustics simulation of rotorcraft.

COMPUTATIONAL FLUID DYNAMICS AND MULTIPHASE FLOWS

Robert F. Kunz, Ph.D., Pennsylvania State University rfk102@psu.edu

Research interests and activities are in the areas of computational fluid dynamics, multiphase flows, turbomachinery, hydropropulsion, reactor thermal-hydraulics and turbulence modeling.

STRUCTURAL DYNAMICS AND ACTIVE STRUCTURES

George A. Lesieutre, Ph.D., University of California, Los Angeles
Director of Graduate Studies and g-lesieutre@psu.edu
Associate Director of Center for Acoustics and Vibration

General research interests are motivated by aerospace vehicle applications, and include materials and controls for precision structures, vehicle dynamics and control, and systems engineering. Present activities address concepts for morphing aircraft structures, the dynamic behavior of elastomeric components in rotorcraft applications, piezoelectric actuators for structural control, energy harvesting using piezoelectric materials, and the nonlinear dynamics of particle dampers. Other research addresses the dynamic analysis of damped structures, structural composite materials with improved intrinsic damping, semi-active vibration control using tunable transducers and shunted piezoelectrics, shape determination for gossamer space structures, structural condition monitoring, and bio-inspired control. Experiments are an important part of much work, and improved measurement methods are also of concern.

MODELING OF CHEMICALLY REACTING FLOWS

Deborah A. Levin, Ph.D., Caltech dal16@psu.edu

Dr. Levin's general area of research is the modeling of chemically reacting, transitional flows which are relevant to a number of important aerospace applications. When we consider the flow Knudsen number, the ratio of a characteristic dimension in the flow to the mean free path, many of the computational tools used to model space flows can also be used to model micro-propulsion systems. The challenges in simulating space-plume and hard body flows involves the development of physical models that provide sufficient fidelity to model thermo-chemical nonequilibrium effects in a computationally feasible manner. The computational flow techniques include direct simulation Monte Carlo and Navier-Stokes methods. Since space flows involve energetic collisions, radiation from chemically formed species may be observed by ground and space optical sensors. Optical radiation modeling of the emissions from these flows is therefore also an important part of the research being performed in the group. Research performed in the group is conducted using three new Beowulf clusters with an emphasis on parallel computing.

COMPUTING AND SOFTWARE

Lyle N. Long, D.Sc., George Washington University
Director of Institute for High Performance Computing Applications and
Co-Director of the Penn State Rotorcraft Center of Excellence lnl@psu.edu

Research interests are in a broad range of computing and information technology including computational fluid dynamics, computational aeroacoustics, particle methods, object oriented programming, parallel computing, robotics, unmanned air vehicles, and knowledge management. We are developing parallel unstructured grid CFD methods for turbulent separate flow over aircraft and helicopters. We are developing vortex methods to simulate flapping wing aerodynamics (birds and UAV's). The CFD and vortex methods run on massively parallel computers and Beowulf clusters. We are also developing robots and unmanned air vehicles which have onboard microprocessors or computers and can be networked together. In addition, we are developing knowledge management techniques and communities of practice for the aerospace community.

AERODYNAMICS, AIRCRAFT DESIGN AND STABILITY AND CONTROL

Mark D. Maughmer, Ph.D., University of Illinois mdm@psu.edu

Research interests are in the areas of aerodynamics, aircraft design, and stability and control. Current activities deal with the design and analysis of airfoils, low Reynolds number aerodynamics, wing planform optimization, uninhabited air vehicles, wind turbines, and experimental aerodynamics.

EXPERIMENTAL FLUID DYNAMICS AND AEROACOUSTICS

Dennis K. McLaughlin, Ph.D., Massachusetts Institute of Technology dkmaer@engr.psu..edu
Department Head

Research interests include experiments on a variety of fluid dynamic and aeroacoustic problems. Experiments are being conducted in the anechoic chamber with forward lift capability on a number of aeronautical applications. Most prominent are the experiments on high speed (transonic and supersonic) jets of various geometries. In these flows helium/air mixtures are used to simulate the high temperature exhausts of the jets. In addition, wind tunnel experiments and flight tests are being conducted as part of the development project for a wing in ground effect flying boat recreational vehicle.

ASTRODYNAMICS, SPACECRAFT DYNAMICS AND CONTROL

Robert G. Melton, Ph.D., University of Virginia rgmelton@psu.edu
Director of Undergraduate Studies

Astrodynamics, spacecraft dynamics and control; trajectory optimization, perturbation analysis of low-thrust orbital motion, orbit determination, dynamics and control of multi-body spacecraft.

ROCKET PROPULSION

Michael M. Micci, Ph.D., Princeton University micci@psu.edu

Research interests centers on rocket propulsion. Both experimental and analytical work is being conducted on the oscillatory burning of solid and liquid rocket propellants and how it affects rocket motor instabilities. Work is also being conducted on advanced propulsion concepts, in particular the heating of propellant gases to high temperatures by the absorption of microwave radiation. Experimental characterization using optical diagnostics of nozzle flows expanding into a vacuum is being undertaken.

TURBULENCE, AEROACOUSTICS AND HYDRODYNAMIC STABILITY

Philip J. Morris, Ph.D., University of Southampton
Associate Director of Institute for High Performance Computing Applications pjm@psu.edu

Dr. Morris's research centers on the modeling and prediction of unsteady incompressible and compressible flows. The work is primarily analytical and computational. Current research projects include: the prediction of noise from high-speed jet flows; the prediction of losses and streaming in thermoacoustic devices; the prediction of cavity and airframe noise; the simulation of blast loading of complex structures; turbulence modeling for free shear flows; and, the prediction of wind turbine noise. Each of these analytical or computational studies is linked closely with an experimental study at Penn State or NASA Langley or Glenn Research Centers.

COMPOSITE STRUCTURES, ROTORCRAFT DYNAMICS, AND AEROELASTICITY

Edward C. Smith, Ph.D., University of Maryland
Co-Director of the Penn State Rotorcraft Center of Excellence ecs@rcoe.psu.edu

Research interests include analytical modeling and experimentation focused on innovative applications of advanced composite structures to aerospace vehicles. Recent research has concentrated on the development of improved methods for the analysis of composite box-beams and rotor blade spars, and the aeroelastic and aeromechanical tailoring of helicopters with composite rotor blades. Research interests related to helicopter and tilt-rotor dynamics also include blade and airframe vibration reduction, gust response suppression, rotor and rotor-body stability augmentation, modeling of bearingless rotors, and helicopter flight simulation. Material damping of advanced composites and elastomerics is also of particular interest.

ASTRODYNAMICS, SPACECRAFT DYNAMICS AND CONTROL

David B. Spencer, Ph.D., University of Colorado dbs9@psu.edu

Research interests include astrodynamics, high accuracy orbit determination, space debris research, spacecraft trajectory optimization, spacecraft dynamics and control, interplanetary trajectory analysis, and space systems engineering.

RESEARCH CENTERS AND PROGRAMS IN ENGINEERING

Penn State Rotorcraft Center of Excellence

The Penn State Rotorcraft Center of Excellence is one of three university research centers in the country which is focused on technical problems specific to rotary-wing aircraft. Funded by the National Rotorcraft Technology Center (NRTC), an organization consisting of Army, NASA, and industry representatives (e.g. Sikorsky Aircraft, Boeing Helicopters), the Penn State Rotorcraft Center involves facilities, faculty and students from the Departments of Aerospace Engineering, Mechanical Engineering, and Engineering Science and Mechanics.

Rotorcraft Center research thrusts include rotor and vehicle dynamics, composite and smart structures, cabin noise, rotor noise, rotor aerodynamics, and drivetrain technologies. In addition to core NRTC support, many Rotorcraft Center research projects are supported directly by industry, US Army, and US Navy agencies. Rotorcraft Fellowships are available to provide additional financial support for outstanding graduate students.

Website: http://www.psu.edu/dept/rcoe/

Contacts:

Dr. Edward C. Smith
Director, Rotorcraft Center of Excellence
The Pennsylvania State University
231D Hammond Building
University Park, PA 16802
Telephone: (814) 863-0966
FAX Number: (814) 865-7092
email: ecs@rcoe.psu.edu

Dr. Lyle N. Long
Administrative Director, Rotorcraft Center of Excellence
The Pennsylvania State University
229C Hammond Building
University Park, PA 16802
Telephone: (814) 865-1172
FAX Number: (814) 865-7092
email: lnl@psu.edu

Institute for High Performance Computing Applications

This Institute was established in 1995 by the College of Engineering. It is an interdisciplinary institute that promotes the use of high performance computers in education and research. The organization was established in consultation with the Colleges of Science and Earth and Mineral Sciences, the Center for Academic Computing and the Applied Research Laboratory. The education emphasis of the Institute is the training of students in the practical use of high performance computers. An interdisciplinary graduate minor in high performance computing is now offered. The research activities of faculty affiliated with the Institute includes acoustics and fluid mechanics in engineering, computational chemistry, and global climate modeling. The Institute has helped to establish a UNIX-based computer classrooms and has also been instrumental in the acquisition of high performance computers for research and instruction.

Information about research and educational activities, as well as computer facilities, are accessible on the World Wide Web at URL http://www.psu.edu/dept/ihpca/

The Institute involves faculty from Aerospace, Mechanical and Nuclear Engineering, Civil and Environmental Engineering, Computer Science and Engineering, Acoustics, Mathematics, Chemistry, Physics, the Applied Research Laboratory, and the Center for Academic Computing.

Contact:

Dr. Lyle N. Long
Director, Institute for High Performance Computing Applications
The Pennsylvania State University
229C Hammond Building
University Park, PA 16802
Telephone: (814) 865-1172
FAX Number: (814) 865-7092
Email: lnl@psu.edu

Center for Acoustics and Vibration

Research in acoustics and vibration is one of Penn State's enduring strengths. The steady growth of research in acoustics and vibration in recent years establishes the Penn State program as the largest and most respected of its kind at a major research university. The Center for Acoustics and Vibration, housed in the Penn State College of Engineering, ensures the continued excellence of acoustics and vibration research in the 1990's.

The CAV has three missions:

to strengthen basic and applied research in related engineering areas;
to foster graduate education in acoustics and vibration engineering; and
to provide a base for technology transfer to industry.

The center consists of faculty, graduate students and staff in nine laboratories throughout the College of Engineering and ARL. These laboratories perform both disciplinary and cross-disciplinary research in areas related to acoustics and vibration. Areas of research activity include:

Active control, adaptive structures, flow-induced noise, machinery prognostics and condition monitoring, propagation and radiation, rotorcraft acoustics and dynamics and structural vibration and acoustics.

Contacts:

Dr. Gary H. Koopmann
Director, Center for Acoustics and Vibration
The Pennsylvania State University
157 Hammond Building
University Park, PA 16802
Telephone: (814) 865-2761
FAX Number: (814) 863-222
Email: ghk@kirkof.psu.edu

Dr. George A. Lesieutre
Associate Director, Center for Acoustics and Vibration
The Pennsylvania State University
229A Hammond Building
University Park, PA 16802
Telephone: (814) 863-0103
FAX Number: (814) 865-7092
Email: g-lesieutre@psu.edu

Propulsion Engineering Research Center at Penn State

With the support and guidance of the National Aeronautics and Space Administration, Penn State has established a Center for Space Propulsion Engineering Research. This is the result of a long history of a commitment to excellence in space-related engineering research and education. Its mission is to enhance and broaden the capabilities of America's engineering community to meet the needs of the expanding space program.

The Center is focusing on five major areas of research: Chemical Propulsion, Electric/Nuclear Propulsion, Advanced Propulsion Concepts, Diagnostics, and Materials.

The Center is housed primarily in the Departments of Aerospace Engineering, Mechanical Engineering and Engineering Science and Mechanics in the College of Engineering, with additional programs in other Engineering departments as well as in the Colleges of Science and Earth and Mineral Science.

Financial support for graduate work is available through either NASA Traineeships or Research Assistantships. NASA trainees receive stipends plus tuition and fees. Stipends for assistantships are competitive. Students involved in Center activities have an opportunity for direct interaction with NASA installations.

Contact Person

Professor Robert J. Santoro
Director
Propulsion Engineering Research Center
Research Building East
The Pennsylvania State University
University Park, PA 16802
Phone: (814) 863-NASA
FAX Number: (814) 865-3389

APPENDIX A

Safety Manual

AEROSPACE ENGINEERING DEPARMENT

SAFETY MANUAL

Prepared by the Aerospace Safety Committee

Approved by the Aerospace Engineering Faculty
February 1990

I, ______________________________________, have read the Aerospace Engineering Department Manual on Safety and agree to follow all safety procedures, as described in the guide, when using laboratories and equipment located in the Aerospace Engineering Department. I recognize it is solely my responsibility not to endanger myself and/or other students, staff, or faculty through unsafe practices.

____

Signature Date

Return this form to the main office of Aerospace Engineering

SAFETY MANUAL

Aerospace Engineering Department

Contents

February 1990

I. INTRODUCTION

The objective of any safety program is to provide a safe working environment in which the hazards to all personnel are minimized. In order to accomplish this goal, safety must be the concern of all members of the institution. Suitable procedures must be devised and followed where potential hazards exist. Common sense must be relied upon to avoid accidents, and expedience is never an excuse for unsafe activities. This information booklet describes the safety regulations and procedures for the Aerospace Engineering Department. These procedures should be followed to ensure a safe environment for all our students, faculty and staff. Safety in our teaching and research laboratories are a direct concern of all the faculty, staff and graduate assistants involved.

II. SAFETY REGULATIONS

Posted in Room 233 and on our Departmental bulletin boards are the University instructions regarding accidents. These instructions include the appropriate telephone numbers and procedures to follow in case of an accident. In addition, it is important to note that: all accidents must be reported to the department office as soon as possible. In the case of an injury, please provide a complete description of the accident and the nature of the injury.

Employees are expected to work in a safe manner, using common sense to avoid accidents. Urgency of completing a test or the use of expedient procedures or equipment is no excuse for taking chances in the laboratory with unsafe conditions. However, even in situations where conscientious attention to safety is the rule, accidents can occur. When an accident does occur it is vital to follow established procedures which will insure the safety of all personnel involved. Once these procedures have been followed, proper reporting of the accident to departmental personnel should follow.

1. An individual is not permitted to work alone at a potentially hazardous task. For example, graduate students or staff are not allowed to operate power tools or similarly dangerous equipment at night unless a companion is in the immediate area.

2. Safety glasses and face shields are available in our machine shop area. Wear them when operating power tools, when around glass that might shatter, when using compressed gases, when working on pressure line connections, etc.

3. When operating electrical equipment avoid chances of grounding one part of your body while using your hands near “hot” lines. “One hand in the pocket” is a good rule. Make sure that your hands are completely dry when handling electrical tools. Don’t experiment with circuits you don’t understand; call a specialist.

4. Accumulation of fumes from volatiles such as gasoline is a great hazard. Use proper ventilation and fume hoods when possible.

5. Handling of compressed gas cylinders should be done with respect afforded to any potentially explosive material.

6. Storage of chemicals is not allowed in refrigerators unless the refrigerator is specially marked suitable for chemicals.

7. Do not block the inlet section of high mass flow rate rotating machinery. These areas should be well guarded with safety cages etc. in order to avoid foreign material suction.

8. Always use earphones when operating noisy test rigs such as axial flow fans, pumps, etc.

These items by no means cover all the problem areas: they do serve as examples. Experimental set-ups of a potentially dangerous nature (explosion, high voltage, high speed rotating machinery, experiments with propellants, etc.) are not to be operated until inspected and approved by our safety committee. It is the responsibility of the PRINCIPAL INVESTIGATOR to contact the safety committee when inspection is required. The committee recommendations will be reviewed by the Department head prior to approving continued operation of any equipment that offers a potential hazard to personnel.

III. SAFETY IN THE LABRRATORY

A. Undergraduate in the Laboratory

With Departmental laboratories operating at full student capacity, the introduction of new laboratory projects and exercises result in increased chances of accidents. It is the direct responsibility of EACH FACULTY ADVISOR concerned with laboratory work to:

1. Take every safety precaution in designing and directing laboratory work.

2. Regularly observe students in action and to watch for unsafe practices and unsafe equipment. Encourage reporting of potential hazards.

SOME EXAMPLES OF HAZARDS ARE:

High voltages.

Eye hazards such as chemicals, compressed air or steam leaks, chipped and hammering
(SAFETY GLASSES ARE REQUIRED).

Rotating and moving machine parts, such as unguarded coupling or shaft ends that could snap clothing.

Smoking with volatile, combustible solids, liquids or gases nearby.

Compressed gas cylinders.

Laser radiation.

Loose clothing, long hair, wearing jewelry around rotating equipment.

Involving with electrical and welding if you are wearing soft contact lenses without a protective glass.

Using portable cassette players etc. with long/loose earphone cables when you are around rotating machine parts.

Graduate Students in the Laboratory

The Aerospace Engineering Department has a large and growing research program which involves a wide variety of sophisticated equipment and apparatus. Some of these research activities may involve potentially hazardous situations and thus require specific procedures for safe operation. Examples of such research areas include those involving high temperature and pressure conditions, concentrated energy sources, high power lasers, rotating machinery with high mass flow rate, high voltages, and liquid/sold propellants.

It is the direct responsibility of EACH FACULTY ADVISOR and GRADUATE STUDENT that safe procedures are observed in the laboratories.

THIS RESPONSIBILITY INCLUDES:

1. Taking appropriate safety precautions in the design and operation of each experiment.

2. Assuring that students and staff engaged in operating equipment are familiar with its operation and potential hazards.

3. Providing appropriate safety equipment in the laboratory. (safety glasses, earphones, respirators, etc.)

4. Where appropriate, start-up, shut-down and also EMERGENCY SHUT-DOWN procedures should be developed and posted.

5. Assuring that students are familiar with university and departmental safety and accident procedures.

6. Assuring that students and researchers are well informed about the locations of safety/emergency/ first aid material.

IV. SPECIFIC LABORATORY SAFETY PROCEDURES

A. SHOP SAFETY AND PROPER USE OF MACHINES

Power tools can cause injury if precautions are not taken. The tools in the shop work area are there for your use. It is expected that students will follow safe shop practices when using them.

Some basic procedures to follow to prevent abuse of the machines and possibly your person are:

1. Safety goggles must be worn when operating any power tools. Also, when hammering or using a punch, chips can fly off these tools. Goggles are available in the machine shop area.

2. When operating any power tool, jewelry, such as rings, bracelets, earrings, loose clothes (i.e. ties) etc., should be removed.

3. Individuals who have long hair should sue a hairnet or other suitable means to prevent hair from being caught while operating any power tools.

4. Drill press – material being drilled should be secured to the table using a drill vise or other suitable clamping arrangement. Wear goggles, as drill bits can shatter. Be especially careful when drilling sheet metal or any thin materials. Drill bits frequently grab the material when the bit "breaks through". This will instantly spin the workpiece, you then have something similar to an electric blender with the blades exposed; not good for the hand that is trying to hold the piece. Be extremely careful.

5. Bandsaw – the bandsaw is equipped for cutting metal only. Avoid cutting sheetmetal, it tends to grab the teeth on the blade, removing them in short order. Never push a work piece with your hand or fingers in the same plane as the blade. Should your hand slip, you may find yourself cutting your hand or fingers. Always adjust the blade guide so it is just above your workpiece. This keeps the blade in alignment and vertical. The blade may come off its rollers if this isn't done.

6. Grinder – always wear goggles. Never stand directly in front of the wheel, your piece can be grabbed or thrown by the wheel, often quite violently. Also, never grind wood, aluminum or softer metals, or plastic on a grinder. Particles of these materials become clogged in the wheel, ruining its effectiveness. Clogging can unbalance the wheel which can cause it to break and explode. Do not grind on the side of the wheel. This can shatter the wheel.

7. GENERAL – be courteous and professional. Horseplay doesn't belong around power tools, someone could fall into the machine, the distraction could cause another to have an accident etc. Also, clean up after yourself when you are done, the debris left behind could lead to an accident.

B. LASER SAFETY

Lasers are utilized in a variety of research programs within the department and when operating in a proper manner thy do not pose a significant safety hazard. However, if operated improperly they can pose significant electrical hazards as well as obvious hazards to eyesight. The following guidelines should be followed when operating any laser system:

1. Do not attempt to use any laser unless you are familiar with its operation and potential hazards and classifications (ANSI-2-I36 Standard).

2. Where appropriate, use laser safety goggles designed for wavelength and power output of that laser.

3. Do not override the safety interlocks intended to prevent operation of the laser. For example, most laser systems prevent operation with the cover off the power supply or laser cavity (plasma tube).

4. When optical elements such as lens, prism, etc., are used with the laser, be careful about specularly reflected beams which result at each surface. These should be blocked to protect personnel in the lab from potential hazards. A neutral density filter on the laser beam should be utilized during the alignment of the optical component in addition to a safety goggle designed for that laser.

5. Never look directly into the laser beam.

6. Never allow the beams to cross windows or any other opening existing in the laboratory., The beams may be dangerous for others outside the lab.

7. It is a good idea to remove jewelry from fingers.

8. Make sure that your hands are completely dry before you switch a power supply on. This is especially important when operating a water-cooled laser power supply.

C. COMPRESSED GAS CYLINDERS

Compressed gas cylinders are safe for the purposes for which they are intended. Serous accidents connected with their handling, use and storage can almost invariably be traced to abuse or mishandling. The following rules cover the main safety rules to be observed in handling compressed gas cylinders. Some information specific to certain gases is included.

1. Compressed gas cylinders should always be moved using a cylinder cart. A cylinder cart is provided for that purpose in Room 125 Hammond. The cart must be returned to that area upon completion of the transfer.

2. All compressed gas cylinders should be securely chained and stored only in approved areas.

3. Do not drop cylinders or permit them to strike each other violently.

4. Make sure the regulator to be used is appropriate for the gas and the cylinder pressure. Regulators or pressure gauges for use with a particular gas must not be used on cylinders containing different gases.

5. After attaching the regulator and before the cylinder valve is opened, see that adjusting screw of the regulator is released. Open the cylinder valve slowly, never permit gas to enter the regulator suddenly.

6. Before the regulator is removed from cylinder, close the cylinder valve and release all gas from the regulator.

7. Never store cylinders near high flammable substances, such as oil, gasoline, etc.

8. All cylinders should be protected against excessive rise of temperature. Cylinders may be stored in the open but in such cases should be protected against extremes of weather (ice, snow, direct sunlight in summer, radiators or open flames, etc.).

9. Store full and empty cylinders in separate locations to avoid confusion. When returning empty cylinders, remove lower portion of the shipping tag attached to the cylinder. Close the valve and see that the protective caps and nuts for valve outlets are replaced before shipping empties.

D. MERCURY SPILLS

The following steps should be taken in case of an accident involving a mercury spill.

1. Do not attempt to clean the mercury in the contaminated area. Mercury breaks into tiny particles and further contaminates the area. Special equipment is needed to ensure that contamination is controlled.

2. Mark the contaminated area.

3. Do not walk on the contaminated area.

4. Turn on the air exhaust if available.

5. Leave the Room immediately.

6. Contact the University Environmental Health & Safety Office immediately (865-6391) and notify the Department as soon as possible.

E. CHEMICALS

When using any chemicals be sure that you are knowledgeable concerning their properties and hazards. Material Safety Data Sheets (MSDS) are available and should be read for all chemicals. The University Environmental Health & Safety Office (865-6391) has a large collection of MSDS and should be contacted for copies. Always wear safety glasses and, if appropriate, suitable gloves or other required clothing. All chemicals should be stored in suitable cabinets. Chemical storage areas, hoods, and work space should be neat and well organized. If any spills or leaks occur, please inform personnel in areas below or adjacent to the spill so that appropriate measures to protect personnel and equipment can be made.

F. ELECTRICAL HAZARDS

1. Only qualified personnel are allowed to work on electrical equipment or energized lines.

2. Sparks or smoke from a motor or other electrical equipment can indicate a shock or fire hazard. Turn off the power at once and report the condition promptly to the electric technician in the department.

3. Electrical equipment should not be operated in wet areas. Experiments using water (water channels or water tables) should be designed extremely carefully in terms of electrical insulations and grounding. Water dripping on electrical machinery (transformers and motors) may cause explosions.

4. Experiments involving electric heater power in excess of 10 KW should be supervised very closely and carefully by the faculty advisor responsible for the facility. Heater connections should be checked thoroughly before switching on the heaters. The power lines should also be protected by appropriate thermal circuit breakers.

5. Electrical equipment with frayed or cracked cords should not be used until the cord is replaced.

6. Maximum attention should be exercised not to have excessive amounts of extension cables lying on the ground level in any laboratory.

7. Remove rings and jewelry which could result in electrical contact while working on electrical equipment.

Acknowledgment

Preparation of this safety manual was aided by reference to the procedures used by the Departments of Engineering Science & Mechanics and Mechanical Engineering. Their careful effort in preparing the original documents is appreciated.

EMERGENCY TELEPHONE NUMBERS

POLICE SERVICES 863-1111

FIRE or ACCIDENT or GAS LEAK or BOMB THREAT. 110

AMBULANCE . . . . 110 or 863-1111

PHYSICAL PLANT (steam, electricity, etc.) 865-4731

EMERGENCY PROCEDURES IN CASE OF FIRE

Location of nearest fire extinguisher (posted in labs)
Location of nearest alarm (throughout building)

(1) SOUND THE FIRE ALARM

(2) DIAL 110

(3) GIVE YOUR NAME AND THE LOCATION OF THE FIRE
(ROOM ______ Hammond Building)

(4) PROCEED TO THE NORTH EAST CORNER OF PARKING LOT BROWN A

(5) DO NOT LEAVE THIS AREA UNTIL INSTRUCTED TO DO SO BY APPROPRIATE UNIVERSITY OFFICIALS

APPENDIX B

STANDARD FORMS

- Graduate Degree Program Plan Approval Form
- Graduate Degree Semester Plan Approval Form
- Check-Off Sheet for Graduate Students Departing PSU
- Exit Forms

Department of Aerospace Engineering
The Pennsylvania State University

GRADUATE DEGREE PROGRAM PLAN APPROVAL FORM*

DATE: __________________ PROGRAM: MS_______ M ENG_______ PhD_______

FROM STUDENT:____
Last First Middle

TO ADVISOR:____

PART 1: THESIS TOPIC

- ____
- Will thesis satisfy core experimental requirement for Ph.D.? _____ Yes ____ No

PART 2: PROPOSED COURSE OF STUDY

	Course No.	Course Title	Semester	Crs.	Requirement(s) Satisfied
1.	_____	_____________	________	___	
2.	_____	_____________	________	___	
3.	_____	_____________	________	___	
4.	_____	_____________	________	___	
5.	_____	_____________	________	___	
6.	_____	_____________	________	___	
7.	_____	_____________	________	___	
8.	_____	_____________	________	___	
9.	_____	_____________	________	___	
10.	_____	_____________	________	___	
11.	_____	_____________	________	___	
12.	_____	_____________	________	___	
13.	_____	_____________	________	___	
14.	_____	_____________	________	___	
15.	_____	_____________	________	___	

ANTICIPATED DATE OF GRADUATION:____

APPROVED BY ADVISOR: ________________________ DATE:_______________________

*Student should submit copy of approved form to Graduate Program Staff Assistant.

PENNSTATE

1855

AEROSPACE ENGINEERING

GRADUATE DEGREE SEMESTER PLAN APPROVAL FORM

FALL 2003

DATE: ________________ _____ MS _____ MEng _____ PhD

FROM STUDENT: ____
Last First Middle

TO ADVISOR: ____

	COURSE NO / COURSE TITLE	CR.	CORE REQUIREMENT(S) SATISFIED
1.	______________________	____	______________________
2.	______________________	____	______________________
3.	______________________	____	______________________
4.	______________________	____	______________________
5.	______________________	____	______________________
6.	______________________	____	______________________

REMARKS: ____

____

____

APPROVED BY ADVISOR: ______________________________________

DATE: ________________________

THIS FORM MUST BE SUBMITTED TO THE
ADVISOR AND APPROVED BY THE ADVISOR
EACH SEMESTER **PRIOR TO REGISTRATION**

*Student should submit copy of approved form to Graduate Program Staff Assistant.

PENNSTATE

AEROSPACE ENGINEERING

GRADUATE DEGREE STUDENT INFORMATION

FALL 2003

Please complete the information requested below and return to the Graduate Program Staff Assistant. This data is used for several projects within the Department, and it is **CRUCIAL** that your input is received **each semester** (even if nothing has changed, **please complete and return.)**

Thank you!

Last Name:	First Name:
Office Address:	Local Address:
Office Phone:	Local Phone:
Email Address:	

Degree: MS ____ MENG ____ PHD ____	PA Resident: YES NO
Adviser:	☐ Temporary ☐ Permanent
Anticipated Graduation Date: Spring __________ Summer __________ Fall __________	
Thesis Topic/Title/*Specific Research Area:	
Type of Financial Support: _____TA _ OR _ _____RA _ OR _ TAide _____ Fellowship Name ____________________ Other ____________________	

*If you do not have a thesis/topic title, please indicate your specific research area.

PENNSTATE

AEROSPACE ENGINEERING

1855

GRADUATE DEGREE SEMESTER PLAN APPROVAL FORM

SPRING 2004

DATE: ________________ _____ MS _____ MEng _____ PhD

FROM STUDENT: ____
Last First Middle

TO ADVISOR: ____

	COURSE NO / COURSE TITLE	CR.	CORE REQUIREMENT(S) SATISFIED
1.	________________	____	________________
2.	________________	____	________________
3.	________________	____	________________
4.	________________	____	________________
5.	________________	____	________________
6.	________________	____	________________

REMARKS: ____

____

____

APPROVED BY ADVISOR: ____

DATE: ________________________

THIS FORM MUST BE SUBMITTED TO THE
ADVISOR AND APPROVED BY THE ADVISOR
EACH SEMESTER **PRIOR TO REGISTRATION**

*Student should submit copy of approved form to Graduate Program Staff Assistant.

PENNSTATE

AEROSPACE ENGINEERING

GRADUATE DEGREE STUDENT INFORMATION

SPRING 2004

Please complete the information requested below and return to the Graduate Program Staff Assistant. This data is used for several projects within the Department, and it is **CRUCIAL** that your input is received **<u>each semester</u>** (even if nothing has changed, **please complete and return.)**

Thank you!

Last Name:	First Name:
Office Address:	Local Address:
Office Phone:	Local Phone:
Email Address:	

Degree: MS ____ MENG ____ PHD ____	PA Resident: YES NO
Adviser:	☐ Temporary ☐ Permanent
Anticipated Graduation Date: Spring __________ Summer __________ Fall __________	
Thesis Topic/Title/*Specific Research Area:	
Type of Financial Support: _____TA _ OR _ _____RA _ OR _ TAide _____ Fellowship Name ____________________ Other ____________________	

*If you do not have a thesis/topic title, please indicate your specific research area.

CHECK OFF SHEET FOR GRADUATE STUDENTS DEPARTING PSU

DEPARTMENT OF AEROSPACE ENGINEERING
PENN STATE UNIVERSITY

Instructions to the Student: You are responsible for having this form completed and turned in to the Department Head before leaving Penn State.

NAME:____ **DATE:**__________________

M ENG MS PHD (circle one)

NEW ADDRESS:____

____

Home Ph#____________________ **EMAIL:** __________________________________

EMPLOYER:____ **Work Ph#**__________________

EMPLOYER ADDRESS:____

____

Please obtain the signatures of the following individuals. *The Administrative Assistant will sign off only after all other signatures have been obtained.

____________________	Richard Auhl Senior Research Aide	Student has returned all electronic/computer equipment to the electronics shop. Student has returned all tools and lab supplies to the machine shop
____________________	Deb Witherite Accounting Clerk	Student has returned all Dept. keys
____________________	Robin Grandy Graduate Program Staff Assistant	Student has completed all his/her academic responsibilities
____________________	Major Advisor	Student has returned all reports and publications which he/she has borrowed
____________________	George A. Lesieutre Director of Graduate Academic Studies	Scheduled date of thesis presentation for M.S. and Ph.D student. Enter Date:
____________________	Sheila Corl *Administrative Assistant	Student has met all his/her responsibilities
____________________	Student Signature	I will provide the Department and my advisor witl a bound copy of my thesis

DKM/Student File

DEPARTMENT OF AEROSPACE ENGINEERING

GRADUATE STUDENT EXIT INTERVIEW

You are very near to completing a major phase of your life by completing your graduate education. We hope that you have found it rewarding and fulfilling. There is little doubt that your advanced degree will prepare you for exciting new opportunities. Industry and government organizations need people trained with your background.

Our faculty is dedicated to providing our students with the best possible preparation for their chosen careers. We are continually striving to do an even better job of educating our students. To this end I am sure you have noticed the significant and continuing expansion of our faculty and the major laboratory renovations that have been taking place. However, we want to do even better. To do so, we would like to have your opinions on ways we can further improve. That is part of the reason we ask you to complete these forms. We would like to do two additional things: 1) Keep in contact with you as you progress through your career, and 2) Be prepared to provide information to future employers and government officials (for security clearance), in order to serve your interests.

To serve these purposes, we have designed the following forms, which we would like you to complete. Some of the questions are of a personal nature and if you do not wish to answer them, please feel free to decline.

Form No. 1 will have your name on it and will provide us with information on the job market and future career plans. Most of the requested information is obvious but a few remarks may be in order. Under parent's name and address, we are looking for someone more or less permanently situated, through whom we can get in touch with you. This may or may not be your parents. If not, we would appreciate an identification of the person.

Under employment, we would like the name of the companies or schools that you have interviewed with. If you have received an offer, note the approximate amount of the offer, otherwise, note pending or rejected. If the number of interviews exceeds the lines available, simply list those companies that are better known or the ones that made you're a definite offer. Finally, under this item, if you have accepted an offer, we would like to know and approximately for how much.

Form No. 2, the departmental release form, is self-explanatory. Your signing of this form is, of course, completely at your discretion. Please feel free to decline to do so if you feel that, in any way, it violates your right to privacy. I will only say that such a form duly signed and witnessed and placed in your file can make it easier for us to provide information on your background to future employers, etc.

The third form to be completed is the comment sheet. This form is intended to provide feedback from our students concerning the Aerospace Engineering program. We would like to have comments on the curriculum, lab facilities, and any other areas of concern.

As you know, our faculty plays perhaps the most important role in your education. We are continually seeking ways to reward those of our faculty who work the hardest at the instructional portion of their responsibilities. It would be a help to them, to us and to future students if you would identify those faculty who have been particularly effective in their teaching and advising activities.

Thank you for helping in this manner. We look forward to your advising us by mail, phone call, or in person, how you are doing in your future career. I join our faculty in wishing you the very best.

Dennis K. McLaughlin
Professor and Head
Aerospace Engineering

Today's Date: ____________________

GRADUATE STUDENT EXIT INTERVIEW

NAME: ____ MALE FEMALE

SS#:____________________

MEMBER OF ANY MINORITY GROUP: NO YES WHICH GROUP: __________________________

FORWARDING ADDRESS: ____

____

____

PHONE: _________________________ EMAIL: _________________________________

SEMESTER DEGREE CONFERRED: FALL SPRING SUMMER YEAR: ______________

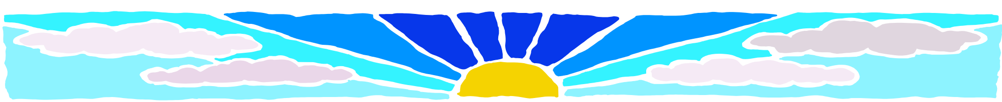
TYPE OF DEGREE: M ENG MS PHD THESIS ADVISOR: ___________________________

THESIS TITLE: ____

_ ____

FINANCIAL SUPPORT FOR GRADUATE SCHOOL (NSF, NASA, TA/TAIDE, ETC.):

____



EMPLOYMENT – Interviewed by:	Offer Received, Pending or Rejected
_________________________________	_________________________________
_________________________________	_________________________________
_________________________________	_________________________________
_________________________________	_________________________________
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_________________________________	_________________________________
_________________________________	_________________________________
_________________________________	_________________________________
_________________________________	_________________________________
_________________________________	_________________________________

Accepted:_________________________ At $________________ per year

To: Dr. Dennis K. McLaughlin
Department of Aerospace Engineering
The Pennsylvania State University
University Park, PA 16802

I hereby grant permission to representatives of the Department of Aerospace engineering of The Pennsylvania State University to release information concerning my academic performance as a graduate student, in response to inquiries from prospective employers or investigations by agencies of the United States Government with regard to my obtaining a security clearance.

____

Signature

____

Date

Witnessed:

__________________________________ ____________________

Signature Date

__________________________________ ____________________

Signature Date

DEPARTMENT OF AEROSPACE ENGINEERING

PROGRAM EFFECTIVENESS SURVEY FOR GRADUATE STUDENTS

* CONFIDENTIAL *

<u>Overall Comments on Program or Courses:</u>	Provide written comments on the curriculum, lab facilities and any other areas of concern.

Written Evaluative Comments	Please provide any comments you wish on the overall teaching effectiveness of particular faculty with whom you have had substantial contact.